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4 October 1979

USSR Report

RESOURCES

(FOUO 24/79)

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ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.039

DEVELOPMENT OF NUCLEAR ELECTRIC POWER STATIONS

Moscow TEPLOENERGETIKA in Russian No 7, Jul 79 pp 2-5

/Article by USSR Deputy Minister of Power and Electrification F. Ya. Ovchinnikov: "Nuclear Power Engineering Is a Quarter Century Old"/

/Text/ The middle of our century was marked by outstanding achievements in nuclear science and technology.

During the postwar years, which were difficult for the country, research was conducted in the area of the peaceful use of atomic energy. And the problem of building a nuclear electric power station was successfully solved: on 27 June 1954 the first AES in the world in the city of Obninsk with an electric capacity of 5,000 kW yielded an industrial current. The building of the Obninskaya AES was the result of a large amount of labor of collectives of Soviet physicists, designers, workers and engineers.

The start-up of the Obninskaya AES became a historical event and showed the way by which world power engineering should be developed in order to provide mankind in the future with a sufficient amount of electric power.

The very first years of operation of the Obninskaya AES showed that a heterogenous graphite-moderated fast reactor with a pressurized water coolant is a reliable "atomic furnace" which generates heat as a result of the nuclear reactions of the fission of slightly enriched uranium. It was first necessary to become accustomed to new standards in the consumption of fuel: just as much energy is released in the fission of 1 ton of U-235 as in the combustion of 2 million tons of coal.

The experience of the long-term operation of the Obninskaya AES made it possible to draw the conclusions that a nuclear power plant based on the chosen type of reactor and traditional steam power equipment is reliable, safe and promising.

Since the very beginning the work with the reactor of the AES has been a good school for power engineers who are working in the field of nuclear science and technology. It is not by chance that the Physico-Energetics

Institute, which is solving important problems of domestic nuclear power engineering, was organized in Obninsk.

The experience of operating the Obninskaya AES made it possible not only to check and confirm the correctness of the initial physical and technical premises, ideas and design solutions, but also to begin the implementation of the plans of industrial AES's.

Following the Obninskaya AES the first sections of the Sibirskaya and Beloyarskaya AES's with an electric capacity of 100,000 kW, the Novovoronezhskaya AES with a capacity of 210,000 kW and the Dmitrovgradskaya AES with a capacity of 50,000 kW were built and successfully started up.

This was the first decade of nuclear power engineering. During this period reactors mainly of two types: channel uranium-graphite and water-moderated water-cooled (under pressure), underwent development and were tested in practice at industrial AES's. It was necessary to gain experience in operating first generation reactors and to identify their positive and negative features during operation in the power system, in order to prepare a new qualitative jump in nuclear reactor building for the construction of more powerful AES's.

From the moment Lenin's plan for the electrification of Russia (the plan of the State Commission for the Electrification of Russia) was adopted until our times power engineering of the Soviet Union has traversed a gigantic path. Today up to 4 billion kWh of electric power are generated in a day in the country, which is half the annual output according to the plan of the State Commission for the Electrification of Russia. Nuclear power engineering, which traces its history from that memorable June day a quarter of a century ago, when the attention of the entire world scientific and technical community and the simple people of the planet was attracted to a small city in Kaluzhskaya Oblast, is beginning to play a more and more noticeable role in the implementation of the far-reaching plans on the development of the power-worker ratio of the country.

The 25th CPSU Congress specified the need to make radical changes during the current five-year plan in the further development of electric power engineering in order to reduce significantly the consumption of organic types of fuel, above all petroleum and gas. The preferential development of nuclear power engineering in the European part of the country, the accelerated development of water power, the construction of large thermal electric power stations in the eastern regions of the Soviet Union, which use the inexpensive coal of the Ekibastuz, Kansk-Achinsk and other deposits, as well as the construction of superlong superhigh-voltage electric power transmission lines for transmitting the inexpensive electric power from the eastern to the central regions of the Soviet Union are called for,

Today about 50 percent of all the organic types of fuel extracted in the country (coal, petroleum, gas, peat, shale) are consumed for the generation of electric and thermal power.

Nuclear power engineering already occupies a secure place in the national economy of many countries, the rate of placement of new AES's into operation and the amount of electric power being generated by them are constantly increasing.

At present about 250 power reactors are in operation in the world, at them about 10 percent of the electric power is generated.

According to available predictions, the total capacity of AES's in the world by 1990 might reach 1.2-1.4 billion kW, and the number of operating power reactors will exceed 1,500.

In the USSR 20 AES's with a total rated capacity of more than 60 million kW are in operation and at various stages of construction.

The construction has been launched anew or the expansion is being continued at the largest nuclear electric power stations in the world with a capacity of 2.5 to 6.0 million kW each, such as the Leningradskaya, Ignalinskaya, Kurskaya, Chernobyl'skaya, Smolenskaya, Novovoronezhskaya, Yuzhno-Ukrainskaya, Kalininskaya, Rovenskaya and other AES's with reactors having a unit capacity of 1.0 and 1.5 million kW.

The four power blocks of the Novovoronezhskaya AES with a total capacity of 1,455 MW, the two 440-MW power blocks of the Kol'skaya AES, the 440-MW power block of the Armyanskaya AES, the two 1,000-MW power blocks each at the Leningradskaya, Kurskaya and Chernobyl'skaya AES's and the power blocks of the Beloyarskaya AES are in the system of operating AES's. The Shevchenkovskaya AES with a 350-MW fast reactor is operating successfully. The experience of operating the 48-MW Bilibinskaya ATETs /nuclear heat and electric power station/ with water-graphite reactors and central heating turbines is interesting. Thus, the installed capacity of the operating AES's has reached about 10 million kW, which is 4 percent of the capacity of all USSR electric power stations. By 1980 the proportion of AES's will increase to 6 percent, and for the European part of the country will be 10 percent.

The many years of experience of operating AES's in the Soviet Union have confirmed their high operating indicators from the point of view of reliability, safety and degree of economy. This can be demonstrated using the example of the Novovoronezhskaya AES (see the table).

Many other nuclear electric power stations also have such high indicators of operation. Thus, for example, the Kol'skaya AES with an installed capacity of 880 MW (two 440-MW water-moderated water-cooled reactor blocks) in 1978 generated 6,404,000,000 kWh of electric power. The utilization ratio of the installed capacity reached 83.1 percent, while the production cost of the electric power is 0.72 kopeck/kWh.

The 2 million kW Leningradskaya AES with boiling-water water-graphite reactors like the RBMK also has high indicators in reliability and the degree of economy. The output of electric power at this station in 1978 was 12.7 billion kWh, while the production cost of electric power was lower than at the thermal electric power stations of the same region. The process of reloading the fuel without shutting down the reactor has been adopted at the Leningradskaya AES, as well as at the Chernobyl'skaya and Kurskaya AES's, which will further increase their economic indicators.

Technical and Economic Characteristics of the Operation of the Novovoronezhskaya AES in 1971-1978

Indicators	Years							
	1971	1972	1973	1974	1975	1976	1977	1978
Nominal electric capacity, MW. . .	1015	1455	1455	1455	1455	1455	1455	1455
Generation of power, millions of kWh.	2027	5413	3674	9664	9138	9750	10080	10516
Utilization ratio of installed capacity, percent	42	61	68	76	71.6	76	79	82
Production cost of electric power, kopecks/kWh . . .	0.948	0.81	0.75	0.644	0.642	0.63	0.63	0.617

During the current five-year plan (1976-1980) nuclear power engineering will make considerable progress in its development. With the total placement of 67 million kW of new capacities into operation more than 13 million kW fall to AES's.

The fulfillment of the far-reaching program of development of nuclear power engineering for the next few decades is raising important questions for designers, builders, installers, power machine builders and operators:

the development of a standardized design using the most efficient layout decisions, for example, the monoblock, the "reactor - turbine" for the VVER-1000 /1,000-MW water-moderated water-cooled power reactor/ with the use of uniform series-produced equipment (this is already being incorporated in the building of the Zaporozhskaya, Khmel'nitskaya, Volgodonskaya, Balakovskaya and other AES's);

the development and use in the plans of automatic control systems of technological processes for increasing the reliability and safety of AES's;

the assurance by the supply ministries and manufacturing plants of the complete supply of equipment, which is specified by standard documents;

the direction of the efforts of the equipment supply ministries toward the development of new types of equipment for AES's being built in seismic regions;

the development and adoption of the flow method of building nuclear power blocks;

the introduction of mechanization plans which make it possible to carry out the installation of assembled elements and machine systems in a strict sequence according to the installation technology;

the constant increase of the level of operation of AES's, the quality of training of the personnel with the use of special simulators.

In the USSR two types of industrial fast reactors are being built--vessel reactors with water under pressure (VVER's) and channel water-graphite reactors (RBMK's /high-power boiling-water reactors/). The use of the two types of reactors makes it possible, on the one hand, to identify the technical and economic advantages and drawbacks of each type; on the other, the design differences of these reactors make it possible to enlarge the group of machine building plants which are being enlisted to manufacture the equipment.

The main direction of the technical improvement of AES's is the increase of the unit capacity and the decrease of the number of types of equipment. Thus, in place of the series of reactors like the VVER-440 with a capacity of 440 MW the building of reactors of this type of the next generation with a capacity of 1,000 MW has begun.

In the USSR the construction of AES's with blocks of RBMK's with a capacity of 1,000 MW each is also being carried out, at the same time the engineering plan of the Ignalinskaya AES in the Lithuanian SSR with RBMK-1500 reactors with a capacity of 1.5 million kW has been drafted and the construction has begun.

At present much is being said and written about the influence of AES's on the environment. The many years of experience of operating Soviet nuclear electric power stations vividly and convincingly attest that radioactive contamination on the grounds of AES's and the surrounding area is not occurring. Moreover, the air basin and area, where nuclear power stations operate, are cleaner than in the region of the location of thermal electric power stations, which discharge ash and sulfur dioxide into the air, in spite of the incorporation of the most modern means of purification. The point is that the fission products remain within the fuel elements during the entire operating life of the reactor. The casettes with fuel elements, which have exhausted their life, are removed by remote control from the reactor and are stored in a holding tank under a deep layer of water until they "cool," and then are sent to a special plant for processing.

Thus, the main condition for ensuring safety is for the uranium fuel elements in casettes not to lose their airtightness under any circumstances. For this the necessary cooling of the casettes with water (or by other means stipulated by the plan) must be provided reliably. In the plans of our nuclear power stations the necessary means are used for cooling the uranium casettes not only during the normal operation of the reactor, but also in various emergency situations.

At the same time the extensive development of nuclear power engineering is raising new tasks and, above all, the further increase of the reliability and safe operation of nuclear electric power stations. The accident which occurred at the nuclear power plant in the United States in the area of Harrisburg (Pennsylvania) reminds us that the problem of safe operation requires constant attention.

The most perfect design decisions, high-quality manufacturing, the reliability of operation of the equipment plus the high skill and strict technological discipline of the operating personnel, their constant observance of the regulations of technical operation and the norms of radiation and nuclear safety are a guarantee that the protection of the environment around nuclear electric power stations will henceforth be ensured.

With the increase of the proportion of AES's in the power systems the problem of regulating the capacity of individual stations arises. Probably it is possible to use AES's for selective operation under variable loads with allowance for the degree of economy of the use of nuclear fuel and on the basis of the condition of the exclusion of premature failure of the fuel elements. Moreover, it is planned to use hydroelectric power stations extensively in combination with AES's to cover the peak part of the load curve, including pumped storage electric power stations. The construction of such an electric power station is called for, for example, at the power complex of the Yuzhno-Ukrainskaya AES. It is also necessary to perform work on discovering for AES's electric power consumers during the night dip in the load.

As is evident from what has been stated, the basis of modern nuclear power engineering in the USSR is thermal nuclear reactors, which will determine its structure in the next few decades.

However, the extensive development of nuclear power engineering is possible only on the basis of the use of fast nuclear reactors, in which the expanded reproduction of the nuclear fuel is ensured and the efficiency of the use of natural uranium is increased several tens of times. It is intended that by that time an economically feasible technology of processing all the irradiated nuclear fuel on an industrial scale should be entirely worked out and the questions of storing the highly radioactive wastes formed during the processing of this fuel should be solved. In the USSR much attention is being devoted to the development of fast reactors.

Industrial fast reactors will be built using a sodium coolant. The gaining of experience in operating an AES with a BN-350 reactor in the city of Shevchenko is of great importance. This station was built on the shore of the Caspian Sea, where there are no sources of fresh water. Some of the generated steam is used for desalinating the salt water at a rate of 120,000 m^3/day. Thus, this AES has a threefold purpose: the generation of electric power, the desalination of sea water and the reproduction of nuclear fuel.

The construction of a station with a 600-MW BN-600 reactor at the Beloyarskaya AES is coming to an end.

In the future plans for the construction of AES's with reactors of an even greater capacity--the BN-800 and BN-1600 with a capacity of 800 and 1,600 MW respectively--will be carried out.

The work being performed at the Institute of Nuclear Power Engineering of the Belorussian SSR Academy of Sciences on using the dissociating coolant Nitrina for fast reactors is of considerable interest.

Thus, the development of power engineering on the basis of fast reactors is the most important long-range task.

Along with the extensive development of large condensation AES's in our country the construction of nuclear heat and electric power stations (ATETs's) and nuclear heat supply stations (AST's) is being planned. The use of sources of central heat supply on the basis of nuclear fuel requires the assurance of additional reliability, radiation and nuclear safety. Some experience of operating such plants exists in the USSR. For example, at the Bilibinskaya AES, which is located on the Chukotka Peninsula, some of the steam is drawn from the four turbines and fed to the boiler plants. Thus, at the same time as the generation of electric power the heating of the settlement of Bilibino is ensured.

Right now at most of the operating AES's the heat from the nuclear reactors goes for the heating of the industrial areas of the AES's and the adjacent settlements. The task is being set of using this heat even more extensively for supplying heat to nearby population centers and heating hothouses.

The technical and economic substantiation of the nuclear heat and electric power station has been worked out. The VVER-1000 with two 500-MW central heating turbines has been taken as the basis. It is planned to build the first such heat and electric power station for supplying heat to the city of Odessa.

Plans are being drawn up for nuclear heat supply stations (AST's), the construction of which will begin near the cities of Gor'kiy and Voronezh.

The engineering plan of ATETs's with VK-500 boiling-water reactors in a reinforced concrete vessel merits attention.

The Soviet Union is giving fraternal assistance to the socialist countries in developing nuclear power engineering. Just two years after the start-up of the first VVER-210 industrial block in the USSR an AES was put into operation in the city of Reinsberg in the GDR. At present AES's are being successfully operated and continue to be expanded in Bulgaria, the GDR and the CSSR. The construction of AES's in Poland, Romania and the Republic of Cuba is being planned.

This year CEMA is marking its 30th anniversary. The implementation of the long-term goal programs of cooperation in meeting the needs for power, fuel and raw materials, as well as in the area of machine building will make it possible to increase the consumption of electric power in the European CEMA countries approximately 1.5-fold. As a result of the cooperation of the CEMA countries the building of nuclear electric power stations with a capacity of about 37 million kW in these states, as well as the joint construction of two 4 million kW AES's on the territory of the USSR, the power of which will be supplied to the European CEMA countries, will be completed by 1990. An agreement on the joint construction of the Khmel'nitskaya AES by the CEMA countries has already been signed and is being implemented.

In the long-term goal program of cooperation in the area of machine building the measures on increasing the output of equipment for nuclear electric power stations by the efforts of the CEMA countries are primary.

The construction of AES's with VVER-440 and VVER-1000 reactors, as well as nuclear heat and electric power stations and nuclear heat supply stations is planned in the CEMA countries by 1990.

Such, in brief, is the path which was begun by USSR power engineering 25 years ago and is being continued today. The successes along this path are significant, the prospects are tremendous. The persistent labor of Soviet scientists, engineers and workers on implementing the outlined program of development of nuclear power engineering in the USSR lies ahead. The extensive development of nuclear power engineering, which began with the construction of the first AES in the world, will be an important contribution to the creation of the material and technical base of communism.

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ELECTRIC POWER AND POWER EQUIPMENT

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POWER REACTOR DEVELOPMENT PLANS

Moscow TEPLOENERGETIKA in Russian No 7, Jul 79 pp 5-9

/Article by G. V. Yermakov: "The Scientific and Technical Problems of the Development of USSR Nuclear Power Engineering"/

/Text/ Nuclear power engineering of the Soviet Union is being formed into a major sector of power generation, its development is based on the use of vessel water-moderated water-cooled reactors like the VVER /water-moderated water-cooled power reactor/ and boiling-water channel reactors like the RBMK /high-power boiling-water reactor/ of various capacities.

The installed capacity of nuclear electric power stations (AES's) in 1980 should be 18 million kW.

The fast rate of introduction of atomic power in the national economy of the country is governed by the status and development of scientific research and experimental design work, which ensures the development of AES equipment which is highly efficient, technologically feasible and reliable in operation.

The development of nuclear power engineering, like any new technology in the next 15-20 years, should be based on the already determined scientific and technical trends, the directions of technical progress, which have already passed through the stages of inquiry and technical research.

The economic efficiency and the degree of development of the technology of producing AES equipment with reactors like the VVER and the RBMK make it possible to believe that in the next few decades the development of nuclear power engineering in the Soviet Union will be based on the further improvement of the reactor plants of these types.

The continuous process of improving the reactor plants is aimed mainly at the introduction of advanced design solutions of the equipment, the achievement of high parameters and the increase of the economic efficiency, reliability and safety. The evolution of the VVER and RBMK reactors is connected first of all with the increase of their unit capacity and that of the main component equipment, which will make it possible to reduce the expenditures on construction and operation, as well as to simplify the system of control of the technological processes of AES's.

Main power blocks with a VVER-1000 reactor with an electric capacity of 1,000 MW and an RBMK-1500 with an electric capacity of 1,500 MW are being built respectively at the Novovoronezhskaya and Ignalinskaya AES's /1/.

The performed research has confirmed the possibility of building VVER-2000 reactor plants with an electric capacity of 2,000 MW with K-2000-70/1500 turbines, as well as plants with RBMK-2400 reactors with a capacity of 2,400 MW with K-1200-65/3000 turbines, which operate on slightly heated steam /2/.

The potential duration of operation of the fuel elements is of decisive importance in the operation of AES's.

The determination of the optimum life of fuel elements belongs to the area of technical and economic research. The increase of the term of their operation reduces the consumption of uranium, the amount of processing of spent fuel elements at a chemical plant, the size of the works and volumes of the storage pits and increases the utilization ratio of the capacity of AES's as a result of the increase of the period between the refueling of the fuel elements. At the same time an increase of the percentage of enrichment, the development of new fuel compositions and so on will be required, which leads to an increase of the cost of the fuel elements.

The AES's in operation and under construction are designed mainly for operation during the base part of the load curve. Scientific research and planning and design work lie ahead on the development of equipment and fuel elements which meet the requirements of operation in variable modes, namely: a load range of 30-100 percent of the nominal capacity; the daily reduction of the load to the level of internal needs or to a "hot" condition for 5-8 hr; the weekly reduction of the load to the level of internal needs or to a "hot" condition for 24-32 hr or 40-55 hr; the rate of increase or reduction of the load is less than for large power blocks operating on organic fuel; participation in the regulation of the current frequency in the systems.

The jackets of the fuel elements are one of the most important barriers which prevent the escape and spread of radioactive contamination.

The specific nature of the operation of the components in nuclear power engineering does not make it possible to fully utilize the available data which have been obtained in other sectors of the national economy. The calculations for strength, which are used in conventional power engineering, do not reflect such specific questions for nuclear power engineering as the effect of neutron irradiation on the properties of construction materials, the high level of cyclical temperatures and pressures, the rapid velocities and flow rates of the coolant and the use of new materials which are not employed in power machine building.

In the process of operation the components and subassemblies of reactor plants are exposed to the influence of the disturbing dynamic forces which arise as a result of the transmission of vibrations from rotating machinery or the effect of the stream of coolant. These disturbing forces lead to the appearance in the system of oscillations which are accompanied by the build-up of fatigue damage in the construction materials.

Radiolytic hydrogen, which leads to a reduction of the plasticity (hydrogen embrittlement), has a harmful effect on the properties of materials. Neutron irradiation increases significantly the appearance of hydrogen embrittlement. The study of these influences will make it possible to combine in the best way the reliability of reactor designs with their technological feasibility and cost.

The increase of the unit capacity of reactors cannot be completely resolved by increasing the heat-transfer surface of the fuel elements. It is necessary to intensify the heat exchange, which is being solved by developing various types of intensifiers on the surface of the fuel elements or channels, as well as by increasing the flow rate and velocity of the coolant. The lack of hydrodynamic theories, which make it possible to predict confidently the efficiencies of various heat-transfer intensifiers, requires a large number of experiments, on the basis of which a hydrodynamic theory of intensifiers should be developed. The increased velocities increase the vibration, wear and probability of the breakdown of the structural components of the plant from exposure to the hydrodynamic forces which arise in the stream of the coolant, which must be taken into account during designing.

When studying the hydrodynamic structure of the stream of water in a transparent model of the vessel of a VVER reactor a very complex structure of the stream was detected, which consists of vortex and jet forms of motion, dead zones, vortex twists with reciprocation around the vertical axis. It is evident that the structure of the stream of water in the reactor vessel, which is required by the design, can be obtained only as a result of many experiments.

The aspiration to increase the energy intensity of the fuel elements requires further research in the area of the thermohydraulics of two-phase mixtures and the critical thermal fluxes in bundles of fuel elements under different operating conditions of reactors.

Improvement of the Main Equipment of AES's

The improvement of the equipment for reactors like the VVER is being carried out especially in the area of developing steam generators. Vertical steam generators are being used in the practice of foreign firms.

The great metal-output ratio of horizontal steam generators as compared with vertical steam generators is explained mainly by the fact that a gravitational system of separation of the steam is used in them, which has a low steam load of about 35 tons/m^2·hr as against 80-120 tons/m^2·hr in vertical steam generators, in which inertial (centrifugal) separators with the axial-flow feed of the steam, which are backed by baffle steam dryers, are installed. The use of this layout for horizontal steam generators requires a significant increase of the volume of the vessel, which makes the steam generators nontransportable.

When analyzing the trends of development of the design layouts of horizontal steam generators it may be thought that their maximum possible heat capacity will be about 750 MW in accordance with the conditions of manufacturing and transportation. To reduce the weight and dimensions of steam generators it is necessary to shift to vertical steam generators in series-produced VVER-1000 reactor plants and later for more powerful plants of this type.

In the technological diagrams of AES's with reactors of the boiling-water type, particularly the RBMK, the steam separators are one of the main components. Boiling-water reactors operate on a "direct" cycle. The steam generated in the reactor is fed directly to the turbine, which requires a high degree of removal of the moisture from it.

In the power blocks with RBMK-1000 reactors four horizontal drum separators with an inside diameter of 2.3 m and a length of 32 m have been installed.

The following basic demands are made on the separation plants of boiling-water reactors: a low moisture content of the dried steam, which should not exceed 0.1-0.2 percent, the small capture of the steam by water (an increase of the proportion of the steam phase in the reactor core can lead to a decrease of the reserve with respect to the critical heat load of the fuel elements, as well as can cause the cavitation of the circulating pumps); high unit steam loads for the decrease of the dimensions of the separation system (the unit steam load in the promising separators of foreign firms reaches 200 tons/m^2·hr); a small value of the hydraulic resistance, which makes it possible to decrease the pressure losses for the pumping of the coolant.

The improvement of the technical and economic characteristics of the separators of plants like the RBMK obviously is connected with the use of vertical drums, which will require new layout decisions and research work.

Standardization of the Power Blocks of AES's

The use of a standard design of the power block at several AES's, which includes not only the equipment, but also the main buildings and structures, such as the main vessel, the special vessel, the storage pits, as well as the plans for the performance of construction and installation work makes it possible to simplify the drawing up of permits for construction and operation and to decrease the construction period and the cost of building AES's.

The flow-line production of identical equipment will ensure the flexibility of the construction schedule and the possibility of transferring equipment and materials from one AES to another. The standardization of equipment is conducive to the increase of its quality during production, as well as of the quality of the installation work and to the supply of spare parts during operation.

At present the All-Union State Institute for the Planning of Electric Equipment for Heat Engineering Structures has drawn up a standardized engineering plan of the main vessel of AES's with a modernized VVER-1000 reactor and K-1000-60/1500 turbines, which will be used at several AES's under construction.

Similar drafting of a standardized plan of AES's with a RBMK-1500 reactor and two K-750-65/3000 turbines lies ahead.

Central Heating

The increasing influence of social conditions on the selection of the fuel for heat and electric power stations (TETs's) and boiler houses, which are located in centers with a considerable concentration of the population, and the requirements of environmental protection dictate the use for them of gaseous or nuclear fuel.

The enlistment of nuclear fuel for providing heat to cities and industrial enterprises is the immediate task of nuclear power engineering, the solution of which will make it possible to reduce substantially the consumption of the petroleum and gas products burnt at TETs's and boiler houses.

The Main Directions of USSR National Economic Development for 1976-1980 provides for the beginning of preliminary work on the use of atomic energy for the purposes of central heating.

An analysis of the performed research shows that under the conditions when the heat loads can be covered both from nuclear heat and electric power stations (ATETs's) and AST's (nuclear heat supply stations), preference should be given to the use of the ATETs, which is more efficient according to all the indicators. The construction of several ATETs's with the installation at them of reactors like the VVER-1000 with a capacity of 1,000 MW and turbines of the condensation-central heating type with the drawing off of steam in the amount of 900 gigacalories/hr from each block is called for. The complete conversion to the construction of ATETs's in the European part of the USSR for the purpose of replacing the petroleum and gas products used at TETs's is limited by the possibility of producing at specialized plants reactor vessels, steam generators, main circulating pumps and other special equipment, which operates at a pressure of 16.0 MPa.

The reactor plants for AST's are substantially simpler since the pressure in them is a factor of 10 lower and unique plant equipment is not required to manufacture them.

The absence of discharges of ash, sulfur dioxide and nitric oxide, which is especially significant for the surrounding population, as well as the negligible need for water and space for siting are merits of the AST's.

The conditions of supplying cities with heat require the location of AST's near or directly in urban residential tracts, since the transmission of the heat carrier over considerable distances requires the additional retirement of suburban and urban land for the laying of steam and hot water pipes and a great expenditure of metal for heating systems (1,000 tons of metal are required per kilometer for the transfer of 1,000 gigacalories/hour). At AST's, as a rule, a three-loop system is used. The heat given off in the core is fed into the intermediate loop, from which it passes through a heat exchanger into the network look, from which hot water is sent to the consumers.

A station produces hot water with a temperature of 150° C, it returns from the consumer with a temperature of 70° C.

Estimated experimental research and the design development of versions of integrated water-moderated water-cooled reactors for AST's, the design of which is distinguished from traditional reactors by the fact that the core, the steam generator and the pressurizer are located in a single high-strength vessel, have already been performed.

With such a design especially favorable conditions are created for the natural circulation of the heat carrier, that is, without circulating pumps of the primary loop.

It is planned to use reactors of this type above all in the area of small-scale stationary nuclear power engineering, which is called upon to ensure the supply of heat to isolated regions.

Integrated reactors with the natural circulation of the heat carrier successfully combine the advantages of reactors like the VVER (a two-loop layout of the heat take-off) and one-loop boiling-water vessel reactors (the lack of a circulation loop of the primary loop) and can faciliate the solution of the following questions:

the localization of accidents in the case of the depressurization of the primary loop (the absence of large-diameter mains, the small degree of branching of the systems of the primary loop and so forth);

the achievement of the maximum unitization of the equipment delivered to the construction site, that is, the decrease of the amount and period of the installation work;

the assurance of the reliable heat removal from the core in case of the emergency, including the complete halt of power supply to consumers for their own needs.

The advantages of reactors like the AST are augmented by the fact that such reactors to a considerable extent can be built by using components, subassemblies and parts, which have been developed and are series produced for reactors like the VVER.

The link of consumers with the AST through the main water urgently raises the question of ensuring radiation safety. The main safety requirements are: the complete elimination of the possibility of radioactive water entering the water mains; the preclusion of harmful gaseous discharges of radioactivity; the guarantee of safety in emergency situations; the reliability of the cooling of the reactor core under all operating conditions.

Assurance of the integrity of the equipment under external influences is achieved by the use of a reinforced concrete containment vessel or the underground location of the reactor.

The indicated circumstances, particularly the completeness and relatively small scale of a possible accident with the discharge of the heat carrier of the primary loop, make it possible to use the reactor of the AST as one of the promising types of nuclear reactors for the purpose of supplying heat.

Here relatively small parameters of the heat carrier of the primary loop are required (a pressure of 1.6-2.5 MPa for heating and industrial heating AST's respectively) which facilitates the task of manufacturing the vessel. The promising nature of AST's increases particularly after the placement into production of vessels which are made from prestressed reinforced concrete.

In principle a reactor of any type can be used for an ATETs. In domestic practice reactors like the VVER and RBMK have been well assimilated and have shown excellent operating results, therefore the decision also to use them at ATETs's is natural. As a result of comparing these reactors from the point of view of better meeting the requirements of operation in the heat supply system the VVER-1000 reactor with two TK-500-60/3000 central heating condensation turbines was used for priority ATETs's.

Much planning and design work is being performed to provide the reactor plants of ATETs's with the technical means for complete safety, which will make it possible to bring the sources of heat as close as possible to the consumers.

One of the directions of this work is the production of the reactor vessel from prestressed reinforced concrete with the placement in it of the steam generator, the separator and the pressurizer, as well as the use of the natural circulation of the heat carrier.

It is believed that the impossibility of an instantaneous rupture of the reinforced concrete reactor vessel, the absence of a ramified system of large-diameter mains and the location of the main radioactive equipment in a single vessel guarantee complete safety. An experimental pilot boiling-water reactor in a vessel made of prestressed reinforced concrete with an electric capacity of 500 MW is being developed.

If it is possible in the near future to solve the problem of building reactor vessels made of prestressed reinforced concrete to make the safety requirements compatible with the economic characteristics, this direction will be very promising.

In the near future atomic energy will make a significant contribution to the generation and consumption of other types of power. In this respect four cases of the use of nuclear thermal energy are of particular interest: for obtaining hydrogen, which is needed by the steel smelting and chemical sectors of industry, for the production of fertilizers and synthetic fuel and as a fuel for engines; for the desalination of water; for generating technological steam, which is used for industrial purposes and for the central heating of cities.

On an industrial scale hydrogen at present is produced by the conversion of natural gas or petroleum and at times by the electrolysis of water. For obtaining hydrogen by the standard conversion of gas or petroleum or by a series of thermochemical reactions, which lead to the heat decomposition of water, a high potential heat (850-1,200° C) is necessary, which can be obtained only in high temperature gas-cooled reactors.

The importance of fresh water in the life of man does not require explanation. In spite of its apparent abundance, the reserves of fresh water are not unlimited. Some regions of the Soviet Union are experiencing an acute shortage of it. A BN-350 pilot industrial fast reactor, which produces electric power and desalinated sea water for the domestic needs of the city, has been in operation at the Shevchenkovskaya AES since 1973. It is possible to enlist for these purposes high temperature gas-cooled reactors, in which steam with high parameters is used in a turbine with counterpressure for generating electric power, while the steam with a pressure of 0.3-0.4 MPa, which has been spent in the turbine, is used in the evaporators for obtaining fresh water.

High Temperature Gas-Cooled Reactors

There is no doubt that in the near future in domestic practice AES's with high temperature helium-cooled reactors (VTGR's) will begin to operate alongside water-cooled reactors. Only about 25 percent of the power fuel resources of the country are being used for the generation of electric power. Therefore, the enlargement of the areas of the use of atomic energy for the more complete replacement of scarce organic fuel involves its introduction in other sectors of the national economy. A reactor like the VVER is capable of meeting the needs of industry for both electric power and technological steam. The experience of operating foreign experimental high temperature helium-cooled reactors has confirmed their basic advantages as compared with other types of reactors: the high temperature level of the helium when it leaves the reactor (950° C for four years in an AVR reactor of the FRG); a higher efficiency of the generation of electric power and therefore less heat pollution of the environment; the better use of resources of nuclear fuel; the possibility of further increasing the temperature of the gas for technological purposes.

For the industrial introduction of nuclear technological power plants it is necessary to ensure a high level of safety of the entire system, including the production and use of "atomic" technological heat and the economic efficiency of the plant.

The possible directions of the use of the heat generated by a high temperature helium-cooled reactor and the approximate temperature ranges required for various processes are cited in the table /3/.

Possible Areas of Use of High Temperature Helium-Cooled Reactors

Process	Reaction temperature, °C	Temperature of the helium on entering the intermediate heat exchanger, °C
Hydrocracking of petroleum	600-750	900-950
Petroleum refining	750-850	1000
Hydrogasification of lignite	700-800	950-1000
Steam conversion of methane	750-850	1000
Gasification of coal with steam	800-900	950-1050
Direct reduction of iron ore	800-900	950-1050
Obtaining synthetic fuel and chemical raw materials (ammonia, methanol and others)	800-900	950-1050
Thermochemical decomposition of water	800-900	1050

Note: A high pressure is also required for the successful occurrence of most of the reactions.

Practically all the directions of the use of "atomic" heat have as their goal the production of hydrogen as a high quality fuel and a valuable chemical raw material.

The heat of high temperature helium-cooled reactors is capable of transforming types of organic fuel, which are low grade, but available in large quantity (coal and others), into high quality, conveniently transported and stored, ecologically clean synthetic fuel (H_2, CH_4 and others) and chemical raw materials--ammonia, methanol, ethylene and others.

In connection with the fact that in accordance with the conditions of nuclear safety AES's cannot be located in the immediate vicinity of the consumers of the power, the possibilities of the thermochemical transmission of power over long distances, which is based on the reversibility of the reaction of the steam conversion of methane ($CH_4 + H_2O = CO + 3H_2$), are being studied extensively. This method consists in the fact that the cooling mixture of gases ($H_2 + CO$), which was obtained from methane by using the heat of the high temperature helium-cooled reactor, is transported by pipelines to the consumer, where, by using catalyzers, they carry out the process of methanization, which is accompanied by the drawing off of the heat which can be used for the generation of steam and electric power and for household consumption.

At present in the USSR and several foreign industrially developed countries scientific research work and experimental designing are being carried out, which are aimed at developing high temperature helium-cooled reactors for obtaining technological heat. Programs for building high temperature helium-cooled reactors which a gas temperature when it leaves the reactor of 950-1,000° C have been elaborated in the FRG and Japan.

The anticipated scale of fuel consumption in the USSR by 2000 requires the extensive enlistment of nuclear power resources which are not only capable of meeting the demand for various types of power, but, which is no less important, will be harmless to the habitat of man.

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ELECTRIC POWER AND POWER EQUIPMENT

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FUELS FOR MAGNETOHYDRODYNAMIC ELECTRIC POWER STATIONS

Moscow TEPLOENERGETIKA in Russian No 7, Jul 79 pp 28-34

/Article by Candidate of Physico-Mathematical Sciences N. A. Kruzhilin, engineer A. G. Rotinov, Candidate of Technical Sciences S. A. Tager, Doctor of Physico-Mathematical Sciences I. T. Yakubov, Institute of High Temperatures of the USSR Academy of Sciences: "On Promising Fuels for Magnetohydrodynamic Electric Power Stations"/

/Text/ Research aimed at the development of open-cycle MHD /magnetohydrodynamic/ electric power stations for large-scale power engineering is presently being performed in the USSR and abroad. Conventional types of hydrocarbon fuels: natural gas, fuel oil and coal, can be used at them. Domestic development on MHD electric power stations operating on natural gas is being carried out most successfully /1/.

As for traditional steam-turbine heat and electric power stations, the fundamental layout of a MHD electric power station, the working principle and parameters of its basic equipment will in many respects depend on the type and characteristics of the fuel being used, the method of its preparation and combustion, which, in turn, will depend on the features of the MHD electric power station. Therefore, the specification of the demands on the fuel of the MHD electric power station and the chamber for its combustion should be made with allowance for many general aspects of the method of the MHD transformation of energy. The latter calls for the combustion of the fuel at a pressure of 0.5-1.0 MPa in a highly heated oxidizer, the obtaining of high temperature (up to 3,000° K) products of practically complete combustion and the imparting to them of the properties of a conducting plasma by the introduction and uniform distribution in them of an easily ionized additive. Potassium carbonate K_2CO_3 is usually used for this purpose (the amount of potassium carbonate should be approximately 1 percent of the weight of the products of combustion).

At an MHD electric power station the combustion chamber is the plasma generator. One of the most important parameters of the plasma, which determine the efficiency of the MHD electric power stations, is its specific electric conductivity. In general it depends on the properties of the fuel being burned, the parameters of the oxidizer, the method of feeding and amount of additive, the parameters of the combustion chamber and the conditions of combustion. In the end the influence of the enumerated factors on the specific electric conductivity σ_0 is determined by the composition and temperature of the products of combustion (the plasma). All other things being equal, σ_0 increases with the temperature.

In this work the influence of the main characteristics of various types of organic fuel on the indicators of the plasma according to the conditions of its use at MHD electric power stations is examined. This makes it possible to draw conclusions about the applicability and comparative efficiency.

Types and Composition of the Fuel

The classification characteristics of the main types of power fuels of the USSR are cited in Table 1 [2]. Moreover, the characteristics of the semicoke of brown coal, which were calculated according to the experimental data of the Power Engineering Institute imeni G. M. Krzhizhanovskiy, are examined. The gas, fuel oil and coals of foreign countries have analogous characteristics, therefore the data of Table 1 can be regarded as generalized data.

The compositions of several promising typical fuels for MHD electric power stations, which were used when making calculations of the specific electric conductivity of the plasma, are cited in Table 2. Pure methane was used as the natural gas, which simplified the calculations without introducing appreciable errors. It was also assumed that coal dust with $W = W^{\text{ги}}$ will be burned at MHD electric power stations. The estimation of the indicators of the plasma when the dust of brown coals is burned was made for the low-ash Berezovka coal of the Kansk-Achinsk Basin and the semicoke obtained as a result of its heat conversion at the temperature of semicoking, which ranges from 720 to 870° K. The selection of Kansk-Achinsk coals is explained by their favorable characteristics (particularly the low ash content) and by the fact that the coals of this basin will be one of the main fuel resources for the development of thermal power engineering of the country.

The consumption of heat for the ionization of the additive when feeding K_2CO_3 in the form of a dry powder leads to the decrease of the temperature of the products of combustion by approximately 40° K, when feeding K_2CO_3 in the form of a 50-percent aqueous solution--by approximately 100° K. In this work it is assumed that the additive is fed in the form of a dry powder and its complete ionization is achieved in the combustion chamber. The thermal conditions of the combustion chamber are judged by the value of the total loss of heat with incomplete combustion and for the cooling of the shell, which is 5 percent of the total enthalpy of the plasma. Air with a coefficient of consumption of $\alpha = 1.0$ is used as the oxidizer.

Table 1. Classification Characteristics of the Basic Types of USSR Power Fuel

(1) Характеристики топлива	(2) "Чистые" топлива		(5) Угли							
	(3) природный газ	(4) мазут	(6) Б	(7) Д	(8) Г	(9) СС	(10) Т	(11) ПА	(12) А	(13) ПКБ
(14) Выход летучих $V^{г}$, %	100*	100*	33–50** / 45	40–44 / 42	39–42 / 40	20–30 / 25	13–19 / 15	7–9 / 8	4	10–18
(15) Органический балласт $(O+N)^{г}$, %	0,5–8	0,3–0,7	18–25	13–18	7,5–12	6,5–10	3,5–7	3,5–7	2,5–3,5	7–11
(16) Теплота сгорания горючей массы $Q^{г}_{н}$, мДж/кг	41,9–50,2	40,2–41,4	23,9–28,0	29,3–31,0	31,4–32,7	32,7–34,1	33,7–34,3	33,1–34,1	33,0–33,5	31,3–32,0
ккал/кг (17)	10 000–12 000	9600–9900	5700–6700	7000–7400	7500–7800	7800–8150	8050–8200	7900–8150	7900–8000	7700–7650
(18) Зольность сухой массы A^{c}, %	0	0,05–0,1	7–40	15–30	12–33	12–45	18–25	5–8	10–25	12–20
Влажность (19)										
(20) рабочая $W^{р}$, %	0	3	18–39	11–14	6–10	6–10	5–10	5–8	5–8	0–2
(21) гигроскопическая $W^{гн}$, %	—	—	7,5–13** / 10	4–7 / 5	1,5–3,5 / 2	1,6–3,5 / 2	1,5–3,5 / 2	1,5–2,0 / 2	2,0	0–2
(22) Отношение C/H***	3–3,5	6,5–8	9,5–12	12–13	13–14	14–19,5	19,5–21	23–24	43	27–45

Key:

1. Characteristics of fuel
2. "Clean" fuels
3. Natural gas
4. Fuel oil
5. Coals
6. B.
7. D
8. G
9. SS
10. T
11. PA
12. A
13. Semicoke of brown coal
14. Discharge of light ash V^{Γ}, percent
15. Organic ballast $(O+N)^{\Gamma}$, percent
16. Heat of combustion of fuel mass Q^{Γ}_{H}, MJ/kg
17. Kcal/kg
18. Ash content of dry mass A^{c}, percent
19. Moisture content
20. Working W^{P}, percent
21. Hydroscopic $W^{\Gamma И}$, percent
22. Ratio of C/H***

*The discharge of light ash for natural gas and fuel oil is arbitrarily taken to equal 100 percent.

**The numerator is the ranges of the changes in the average values for the coals of various deposits, the denominator is the average value for the corresponding brands of coal.

***The ranges of the change of C/H are defined for the working compositions of gas and fuel oil, for the dust of the corresponding brands of coals with allowance for the hydrogen content in the hydroscopic moisture.

Table 2. Estimated Compositions of Typical Types of Fuel

Description	Content of components, percent									
	CH_4	C	H	S	O	N	A	$W^{ги}$	C/H	Q_H, MJ/kg
Natural gas. . .	100.0	--	--	--	--	--	--	--	3	49.85
Fuel oil	--	83.0	10.4	2.8	0.7	0.0	0.1	3.0	7.7	38.74
Coal B	--	58.2	3.9	0.3	19.0	0.5	6.1	12.0	11.1	21.36
Coal D	--	62.5	4.4	1.0	13.8	1.0	12.3	5.0	12.6	23.85
Coal G	--	66.5	4.7	3.5	8.9	1.3	12.1	3.0	13.2	26.84
Coal SS.	--	75.5	4.8	2.0	4.9	1.0	9.8	2.0	15.0	30.53
Semicoke B . . .										
$T_{пк}$ = 720° K. . .	--	73.4	2.5	0.4	9.3	0.4	12.0	2.0	27.0	26.6
$T_{пк}$ = 870° K. . .	--	77.3	1.7	0.4	4.9	0.4	13.3	2.0	40.2	27.1

Determination of the Specific Electric Conductivity of the Plasma

The determination of σ_0 was made with allowance for the real characteristics of the fuel being burned, including the influence of the ash and moisture content on the temperature of the plasma. The method, which was developed for ashless fuels /3/ and was checked by comparison with the entire set of available experimental data, was taken as the basis. The electric conductivity σ_0 depends on the temperature and pressure of the plasma, the hydrocarbon ratio of the fuel, the proportion of oxygen in the oxidizer and the proportion of the additive /3/.

It is known that with the nonoptimal organization of the combustion of coals and the feeding of the additive into the combustion chamber the interaction of the mineral components of the fuel with the additive being ionized is possible, as a result of which some of the additive is captured by clinker. In this case the content of the additive in the plasma is reduced, which entails a decrease of σ_0. In general the capture of the additive by clinker depends on many factors: the type of combustion chamber, the composition and amount of ash in the initial fuel, the organization of the processes of its combustion and the ionization of the additive. Here the layout of the combustion chamber, which influences the collection and removal of the clinker, and the conditions of the contacting of the additive with the clinker and the particles of light ash are of basic importance. The development of combustion chambers, in which this negative phenomenon would be eliminated, is an independent problem. With its successful solution the actual electric conductivity of the plasma will be close to the estimated electric conductivity, which was obtained without regard for the capture of the potassium by the clinker.

However, even if this problem is not completely resolved, the estimated value of the specific electric conductivity can be reestablished by the negligible increase of the feeding of the additive with an inconspicuous decrease of the temperature of the plasma. At present it is impossible to take all these factors into account by means of estimates. An analysis of the experimental data available in the literature on the electric conductivity of the products of combustion of ash fuels has been made /4/. It made it possible to conclude that although the influence of the condensed phase on σ_0 is appreciable, under certain conditions it is comparatively small. Therefore, in this work we disregard the influence of the ash content on the concentration of potassium in the plasma. If necessary it can be taken into account by the introduction of an empirical adjustment factor.

With allowance for what was said above, in this work the determination of σ_0 for the plasma obtained with the burning of different coals was made without regard for the capture of the potassium by the clinker. This made it possible to estimate the influence of the quality characteristics of the fuel on the parameters of the MHD electric power station with the optimal organization of combustion and ionization.

Reactivity

In order to obtain a high temperature of the products of combustion, which is as close as possible to the estimated temperature, it is necessary to ensure the practically complete combustion of the fuel in the combustion chamber with the simultaneous reduction of the heat losses from the cooling of its shells to a very low level (about 3 percent). In this case the total heat losses in the combustion chamber can be limited to the above-indicated values (about 5 percent). The considerable reduction of the dimensions of the combustion chamber as a result of the sharp (as compared with certain power furnace plants) intensification of the combustion processes is the main way to solve this problem. Thus, for different fuels and conditions of obtaining the plasma the time that the products of combustion are in the combustion chamber should be within the range of only 20-80 ms.

The achievement of complete combustion of the fuel and the reduction of the size of the combustion chamber are factors which operate in opposite directions. Their simultaneous effect is possible only with the use of fuels with a sufficiently high reactivity, which allow a considerable intensification of the combustion. Among these fuels are natural gas, fuel oil and coals with a discharge of light ash of $V^r \geq 20-25$ percent. The semicoke of brown coal, which is obtained at a moderate temperature of semicoking, is also characterized by a high reactivity. For it the discharge of light ash is $V^r = 10-17$ percent with a highly active coking base of dry brown coal.

At MHD electric power stations with direct (single- or multiple-stage) combustion fuels with a low reactivity ($V^r < 20$ percent): anthracites (A), semianthracites (PA) and lean coals (T) should not be used.

Moisture Content

The very low moisture content in nature gas and fuel oil does not appreciably affect the temperature of their combustion. Therefore, the mentioned fuels can be used in high temperature combustion without the preliminary removal of the moisture. At the same time an increase of the moisture content in the products of their combustion, for example, by the steam atomization of fuel oil, should not be allowed.

Coals, which always contain moisture, are in a different situation. Thus, the working mass of brown coals (B) contains 18-39 percent moisture, long-flame coals (D) 11-14 percent, gas coals (G) and brand SS from 6 to 10 percent. An increase of the moisture content of the fuel always leads to the progressive decrease of the temperature of their products of combustion. Thus, given the parameters of MHD electric power stations an increase of the moisture content of coals like G and SS from 0 to 5 percent leads to a decrease of the temperature of the products of combustion by 18° K; from 5 to 10 percent--an additional 22° K; from 10 to 15 percent--by 30° K and from 15 to 20 percent--another 37° K. For brown coals and with an increase of the ash content of the fuel the negative influence of the moisture content on the temperature of the products of combustion increases in excess of the indicated values. The described phenomenon is additionally aggravated by the fact that coals with a relatively high moisture content are characterized by a higher content of organic ballast $(O+N)^{\Gamma}$. In the aggregate this reduces the heat of combustion of the fuel mass of the fuel Q_H^{Γ} (see Table 1) and the temperature of combustion.

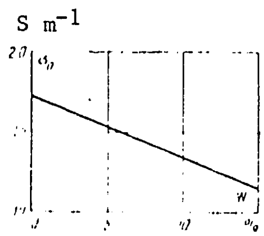


Figure 1. Dependence of the Specific Conductivity of the Plasma σ_0 on the Moisture Content of the Coal SS

Oxidizer--air; excess of air $\alpha = 1.0$; air temperature $T_B = 1{,}800°$ K; pressure $p = 0.8$ MPa; total heat losses in the combustion chamber $\overline{Q} = 5$ percent.

The dependence of the specific electric conductivity of the plasma obtained when burning the dust of coal SS on the moisture content of the fuel is depicted in Figure 1. From the graph it is evident that an increase of the moisture content from 0 to 15 percent decreases the electric conductivity of the plasma to two-thirds. The estimate showed that the decrease connected with this in the temperature of the plasma by 70° K is responsible for only half of the decrease of σ_0. The attendant increase of the moisture content in the products of combustion and the reduction caused by this in the hydrocarbon ratio C/H have the same negative influence on the decrease of the electric conductivity (see below). For the indicated reasons coals with an initial moisture content should not be burned in the high temperature combustion chambers of MHD electric power stations; the combustions chambers should be equipped with pulverization systems with a closed or semiclosed drying of the fuel, in order to feed into the combustion chambers coal dust which has been dried to the hydroscopic moisture content $W^{\Gamma И}$ and to discard the drying agent, bypassing the combustion chambers. From

Table 1 it follows that the average value of W^{rH} for brown coals is 10 percent, for coals of brand D--about 5 percent, G--3 percent and SS--2 percent. The use of closed (semiclosed) drying will make it possible, other things being equal, to increase the temperature of the plasma when burning coals SS by 35° K, coals G--30° K, coals D--40-45° K. When burning brown coals the effect will be particularly great and will be, depending on the initial moisture content of the fuel, 70-120° K and more.

Fresh brown coals and lignites with $V^r \geq 60$ percent, as well as peat with $V^r \geq 70$ percent contain a large amount of organic ballast (24-37 percent) and are characterized by a low heat of combustion $Q_H^r = 21.4-27.2$ MJ/kg (5,100-6,500 kcal) and a hydrocarbon ratio $C/H = 7.5-8.5$. Such types of fuel are not promising for obtaining plasma with a temperature and electric conductivity, which are sufficiently high for MHD electric power stations, even when using pulverization systems with closed drying. Therefore, they are not examined in this work.

The technology of semicoking of brown coals provides for them complete drying and subsequent thermal decomposition without the presence of air. The transportation and storage of semicoke, preferable in a resinified state, will not promote appreciable moistening. Therefore, the working moisture content of this product of the heat conversion of brown coal will be close to zero, which is a very favorable attribute of the semicoke of brown coal.

Ash Content

It is typical of solid fuels to contain mineral ballast. The ash content of coals of practically all the brands fluctuates over a very wide range. This pertains above all to the coals of various deposits within one brand, as well as to a specific coal with different characteristics of its vein and mining technology. On the whole a higher ash content is typical of the coals of the European part of the USSR, as lower ash content is typical of the coals of Siberia.

The presence in the fuel of a mineral component can affect the electric conductivity of the plasma being obtained as a result of the reduction of the temperature and the bounding with it of compounds of the additive. The latter factor has already been examined above.

An increase of the ash content of coals leads to the progressive decrease of the temperature of the products of their combustion and the obtained plasma $T_{\text{пл}}$. Given the parameters of MHD electric power stations an increase of the ash content of dry coal from zero (the conventional ashless mass) to 10 percent leads to a decrease of $T_{\text{пл}}$ by approximately 20° K, from 10 to 20 percent--25° K, from 20 to 30 percent--35° K, from 30 to 40 percent--another 45° K.

The best coals are characterized by an ash content (by dry weight) of about 10 percent. However, their use in USSR power engineering is very limited. The use of coals with $A^c = 20$ percent entails a decrease of the temperature potential of the plasma as compared with coals with $A^c = 10$ percent by $\Delta T = 25^\circ$ K, which can still be regarded as acceptable. However, a further increase of the ash content of coal, for example, to 40 percent, would lead to a loss of the temperature potential of the plasma of 100-110° K, which is now unacceptable.

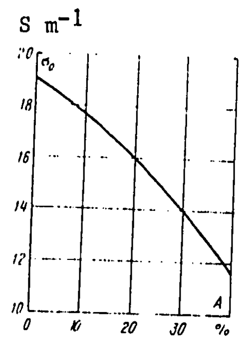


Figure 2. Dependence of σ_0 on the Ash Content of Coal SS (given the conditions indicated in Figure 1)

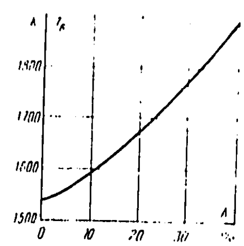


Figure 3. Dependence of the Necessary Air Temperature for Combustion on the Ash Content of Coal SS for Ensuring $\sigma_0 = 10$ S m^{-1}. $\alpha = 1.0$; $p = 0.8$ MPa; $\overline{Q} = 5$ percent.

The decrease of the specific electric conductivity of the plasma given invariable parameters of the oxidizer and the combustion chamber, which is connected with the indicated increase of the ash content of coal SS and the attendant decrease of the temperature of the plasma, is shown in Figure 2. It is evident that an increase of A^c from 10 to 20 percent leads to a decrease of σ_0 from 17.7 to 16 S m^{-1}, that is, 10 percent (relative). A further increase of A^c from 20 to 40 percent would lead (even on the assumption of the lack of interaction of the additive with the clinker) to an additional decrease of σ_0 from 16 to 11.7 S m^{-1}, that is, another 27 percent.

The dependences of the necessary air temperature for ensuring an invariable specific electric conductivity of the plasma of $\sigma_0 = 10$ S m^{-1} with a change in the ash content of coal SS from 0 to 40 percent are presented in Figure 3. From the graph it follows that with an ash content $A^c = 10$ percent air with a temperature of 1,590° K should be fed into the combustion chamber with a total heat loss of 5 percent. With an increase of the ash content to $A^c = 20$ percent it is necessary to increase the air temperature to 1,670° K, that is, by 80° K. If the ash content of the coal increases to 40 percent, it will be necessary to increase the air temperature to 1,890° K, that is, another 120° K (200° in all). It is well known that such a significant increase of the air temperature greatly complicates and increases the cost of the heat exchangers. Therefore, it is always difficult to offset a considerable decrease of the temperature of the plasma as a result of a rise in the ash content of the fuel by the corresponding increase of the temperature of the oxidizer. This is one of the main factors which are responsible for the infeasibility of using high-ash coals at MHD electric power stations. The second reason is the complication of the equipment arrangements and the measures aimed at preventing the loss of the additive in the clinker.

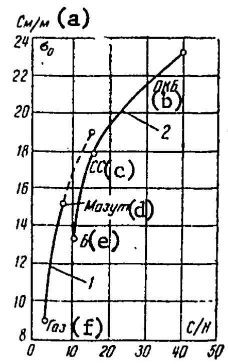
The processes of the drying and heat conversion of coal during its semicoking take place due to the heat which is released during the partial combustion of the fuel itself. As a result the ash content of the semicoke is always higher than the ash content of the initial coal. In order to limit the coal content of the semicoke it is necessary for the initial coal to have as low an ash content as possible. The coals of the Kansk-Achinsk Basin meet this requirement to the greatest extent. All things being equal, the ashing of the semicoke increases as the temperature of the semicoking and accordingly the extent of the heat conversion increase. At the same time the discharge of light ash and the reactivity of the semicoke decrease. Therefore, for the needs of MHD electric power stations it is desirable to carry out the semicoking at a moderate temperature within the range of $T_{пк} = 720-870^{\circ}$ K. For the above-noted conditions it is possible to obtain from the coal of the Irsha-Borodino deposit with an initial ash content of $A^c \approx 10$ percent semicoke with an ash content of 17-20 percent, and from the relatively less ashy Berezovka coal with $A^c \approx 7$ percent semicoke with an ash content of 12-14 percent.

Hydrocarbon Ratio

The total influence of the composition of the organic component of the fuel on the indicators of the plasma is most completely defined by the hydrocarbon number, which is equal to the ratio of the contents in this fuel of carbon and hydrogen (with allowance for the content of the latter in the moisture of the fuel). The typical values of C/H for the main types of fuel are cited in Table 1. The values of C/H for the specific fuels used in this work are cited in Table 2.

The dependence of the specific electric conductivity of the plasma on the hydrocarbon ratio and the ash content for the examined types of power fuel is depicted in Figure 4. The values of σ_0 were determined for identical initial conditions (the parameters of the combustion chamber and the oxidizer), therefore the obtained dependences reflect the influence of the characteristics of the fuel in pure form. Curve 1 corresponds to ashless fuels--gas and fuel oil. The value of σ_0, which would be obtained with the burning of an ashless mass of coal SS, is cited there for comparison. Curve 2 corresponds to coals and semicoke with an ash content $A^c = 10-15$ percent. With an increase of the value of C/H the electric conductivity of the plasma initially increases rapidly, then the curves become flatter. This nature of the dependence is explained mainly by the fact that with low values of C/H the plasma contains many water molecules which have a large diameter of the elastic scattering of electrons. Moreover, the dissociation of the water leads to the appearance of the radical OH, which bonds potassium atoms into molecules of KOH and decreases thereby the number of free electrons in the plasma. The decrease of the total amount of hydrogen in the plasma sharply alleviates these negative effects. Therefore, with an increase of the value of C/H the dependence on it becomes weak, while the values of σ_0 increase more slowly. The location of curve 2 below curve 1 is explained by the above-described negative influence of the ash content of the fuel on the temperature of the plasma, and accordingly on the value of σ_0.

Figure 4. Dependence of σ_0 on the Hydrocarbon Ratio and the Ash Content 1--$A^c = 0$; 2--$A^c = 10-15$ percent; $W = W^{гн}$; the other conditions follow Figure 1 .



Key:

a. S m^{-1}

b. Semicoke of brown coal

c. SS

d. Fuel oil

e. B

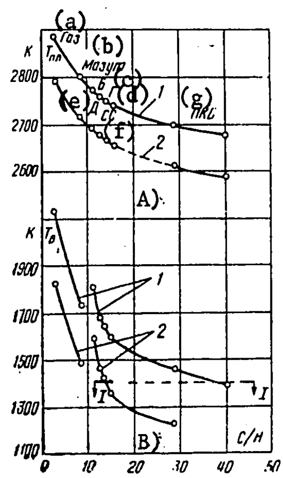
f. Gas

From the graph it follows that among the plasma of "clean" fuels the plasma obtained with the burning of natural gas ($\sigma_0 = 9$ S m^{-1}) has a relatively lower specific electric conductivity. With the use of fuel oil σ_0 increases to 15 S m^{-1}, which is explained by the simultaneous increase of C/H and the temperature of the plasma from 2,855° K (for gas) to 2,910° K. The plasma would have an even higher electric conductivity with the burning of an ashless mass of coal SS, for which C/H = 15 ($\sigma_0 = 19$ S m^{-1}).

Among the plasma of coals which contain 10-15 percent ash the plasma obtained when burning the dust of brown coal has the relatively lowest value of the specific electric conductivity ($\sigma_0 \approx 13$ S m^{-1}) and the plasma obtain when burning SS has the relatively highest value ($\sigma_0 \approx 18$ S m^{-1}). The maximum value of $\sigma_0 = 21-23$ S m^{-1} can be achieved with the burning of the semicoke of brown coal. High values of σ_0 with the burning of coals and the products of their conversion as compared with gas and fuel oil are achieved in practice only by means of higher values of C/H, since the temperatures of the plasma for them differ little (about 15° K for the plasma of coal B as compared with the plasma of gas and for the plasma of coal SS and the semicoke of brown coal as compared with the plasma of fuel oil).

Figure 5. Dependence of the Temperature of the Plasma (A) and the Corresponding Necessary Air Temperature (B) on the Hydrocarbon Ratio C/H

1-- $\sigma_0 = 10$ S m^{-1}; 2-- $\sigma_0 = 7$ S m^{-1}; I-I--anticipated area of use of tube air heaters; $W = W^{гн}$; the remaining conditions follow Figure 1.



Key:

a. Gas
b. Fuel oil
c. B
d. G
e. D
f. SS
g. Semicoke of brown coal

The dependences of the temperature of the plasma, which has an identical specific electric conductivity for all types of fuels of $\sigma_0 = 10$ S m^{-1} (curve 1) and 7 S m^{-1} (curve 2), on the hydrocarbon ratio of the corresponding fuels are cited in Figure 5A. It is evident that with an increase of C/H the temperature of the plasma drops sharply. Thus, for natural gas it is 2,880-2,790° K (the larger value is for $\sigma_0 = 10$ S m^{-1} and the smaller value is for $\sigma_0 = 7$ S m^{-1}), for fuel oil 2,800-2,710° K, for the dust of coals with $V^{г} \geq 20$ percent from 2,770-2,680° K to 2,740-2,660° K. For the semicoke of Berezovka brown coal the temperature of the plasma for the mentioned conditions would be about 2,680-2,600° K.

In Figure 5B it is shown, what air temperature is necessary in order to ensure the corresponding value of the temperature of the plasma. It is evident that to ensure $\sigma_0 = 10$ S m^{-1} when burning natural gas air with a temperature of 2,130° K should be fed into the combustion chamber, when burning fuel oil--1,730° K, when burning coal dust--from 1,810° K (coal B) to 1,590° K (coal SS), when burning the semicoke of brown coal--from 1,460 to 1,390° K. To obtain plasma with $\sigma_0 = 7$ S m^{-1} a lower air temperature is needed than when $\sigma_0 = 10$ S m^{-1}: 310° K lower when burning gas, 250° K when burning fuel oil and 230° K when burning coal dust and the semicoke of brown coal.

It is well known that different heat exchangers and materials (including highly refractory) correspond to each level of high temperature of the oxidizer (air). According to a preliminary evaluation of the available data, air with a temperature of up to 1,400° K perhaps will be able to be obtained in tube heaters made from special alloys, which are heated by the main steam of the products of combustion, which comes out of the MHD conduit and contains the additive. MHD electric power stations, which burn the semicoke of brown coal with $\sigma_0 \approx 10$ S m^{-1} or coals SS and the semicoke of brown coal with $\sigma_0 \approx 7$ S m^{-1}, might meet this condition. In contrast, for the other types of fuel it will be necessary to heat the air more with "clean" gases without ash and an additive in regenerative heat exchangers made from refractory ceramics and with independent combustion chambers. Such heat exchangers are, as a rule, more expensive, and the cycle diagram of an MHD electric power station with the independent heating of the heat exchangers is less efficient.

The increase of the level of air temperature progressively complicates and increases the cost of heat exchangers, increasing their proportion in the capital expenditures on the construction of MHD electric power stations. On the other hand, the use of fuel with a lower initial temperature can decrease the efficiency of the MHD transformation of energy. Therefore, the indicated circumstances should be taken into account when making comparative technical and economic appraisals of versions of MHD electric power stations which run on different types of fuel.

Sulfur Content

One of the anticipated advantages of MHD electric power stations as compared with traditional thermal electric power stations is the possibility of the significant removal from the products of combustion of sulfur oxides by their bonding in the gas loop of the steam generator with compounds of the potassium additive. The amount of additive, which is normally fed into the combustion chamber (about 1 percent potassium from the weight of the products of combustion), is sufficient for bonding about 4 percent of the sulfur contained in the fuel. At MHD electric power stations sulfur compounds like CS, SO_2 and others do not significantly influence the electric conductivity of the plasma. This is caused by the moderate value of the diameter of the elastic scattering of the electrons on these molecules. The influence of the compounds of alkaline metal, which contain sulfur atoms, at high temperatures is also minor.

What has been said above attests to the possibility in principle of using sulfur-containing fuels at MHD electric power stations without the threat of appreciable pollution of the air with sulfur oxides and, probably, without damage to the components of the steam generator and the gas loop as a result of low temperature sulfur corrosion. In this case the need to development special and expensive equipment to trap the oxides following the model of traditional thermal electric power stations disappears. In bound form the sulfur compounds should be removed from the gas loop of the MHD electric power station through the equipment for trapping the additive, while the sulfur should be removed in the additive recovery system.

Semicoke of Brown Coals

The semicoke of brown coal for the present is obtained at pilot industrial facilities following the plan of the Power Engineering Institute imeni G. M. Krzhizhanovskiy. Many questions of its large-scale production and long-distance shipment have to be solved. Of great importance for the practical accomplishment of this development and subsequent introduction is its technical and economic substantiation. In this respect the long-range significance of the semicoke of brown coal for MHD electric power stations is of interest. Among the general anticipated merits of semicoke is the higher heat value of the product as compared with the initial coal and the elimination of the tendency for spontaneous combustion.

The thermotechnical advantages of the semicoke of brown coal for MHD electric power stations consist in the fact that with a practically zero moisture content and a moderate ash content it provides the same high combustion temperature as the best coals like SS and has the same hydrocarbon ratio as anthracite. However, unlike the latter the semicoke of brown coal has a good reactivity, which makes it possible to burn it efficiently in high temperature combustion chambers. According to all the indicated properties the semicoke of brown coal is superior to the known natural coals as a fuel for MHD electric power stations.

Comparative Prospects of the Use of Different Types of Fuel

"Clean" fuels--natural gas and fuel oil--make it possible to significantly simplify the fuel system of MHD electric power stations, actually the combustion chambers and their fuel supply systems. When burning gas the danger of contaminating the heating surfaces of the steam generators with ash deposits is eliminated and the system of removing and reclaiming the additive is simplified. This applies to a somewhat less extent to fuel oil. Therefore, the use of "clean" fuel in the main MHD power blocks is regarded as a condition which is capable of facilitating the solution and the industrial assimilation of the new efficient method of transforming energy.

For powerful condensation thermal electric power stations, which operate primarily on a base load, coal should be considered the main promising fuel. This is connected with its very great distribution, as well as with the planned further use of petroleum and gas primarily in other sectors of the national economy (the chemical industry, transportation).

Among the anticipated merits of coal-powered MHD electric power stations are:

the protection of the walls of the high temperature components of the station with a slag lining which is constantly being replaced;

a higher electric conductivity of the products of combustion of moderately ashy coals and especially the semicoke of brown coal as compared with "clean" fuels.

The first circumstance significantly facilitates the solution of the problem of durable high temperature refractory materials, the second decreases the level of the necessary temperature of the oxidizer, simplifies and reduces the cost of the appropriate heat exchangers.

Along with this when developing coal-powered MHD electric power stations the need arises to solve many specific controversial questions, which are absent or are solved relatively more simply when using "clean" fuels. Such questions are the feeding of coal dust into the combustion chamber under pressure and the removal from it of the trapped clinker, the prevention of the loss of the additive in the clinker and the development of the appropriate combustion chambers, the electrical insulation of the combustion chambers along the lines of the feeding of the dust and the removal of the trapped clinker, the removal of ash deposits with the additive from the heating surfaces of the steam generators, the removal and recovery of the additive in the presence of ash, the partial gasification (or heat decomposition) of the coal for the heating of the regenerated air heaters with "clean" fuel.

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ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.31.002.2

BUILDING FACILITIES FOR POWER ENGINEERING REVIEWED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 6, Jun 79 pp 2-6

[Article by P.P. Falaleyev, first deputy minister of power engineering and electrification of the USSR: "Basic Directions of Increasing the Effectiveness of Power Engineering Construction"]

[Text] The creation of a reliable base for electrification of the country is a decisive condition of development of the socialist economy and building the material and technical basis of communism.

In recent years during solution of the problem of increasing the effectiveness of power engineering construction substantial qualitative changes have been made in the construction of power engineering facilities: a program of construction of thermal electric power plants with power blocks with a capacity of 210-300 megawatts was fulfilled; construction of electric power plants with blocks of 500 and 800 megawatts was developed; very large thermal electric power plants with power blocks of 800 megawatts were built; plans were developed and construction is under way on thermal electric power plants with a capacity of 4,000,000-6,400,000 kilowatts with power blocks of 500 and 800 megawatts and of large nuclear electric power plants with power blocks with a capacity of 1,000 megawatts; and a pilot power block is being erected with a capacity of 1200 megawatts at the Kostromskaya GRES.

The construction of thermal electric power plants has been put on an industrial basis. Work is being continued for unification of planning decisions: a plan has been created for series-produced TETs-ZIGM, according to which at present more than 14 electric power plants are being built, and a plan has been developed for a series-produced TETs using solid fuel (ZITT).

Solutions have been found to technical questions of creating powerful hydroelectric power plants with high dams made of local materials and poured reinforced concrete under the difficult conditions of Siberia and in regions with high seismic activity.

In electric network construction developed on a large scale was the industrial technology of erecting electric power lines and substations with a voltage of 500 and 750 kilovolts.

Along with this it is necessary to note serious shortcomings holding back the increase in effectiveness of power engineering construction.

In the current year the assignment for introduction of energy capacities was not fulfilled, and the annual introduction of capacity was stabilized at the level of 10-11 million kilowatts, which does not satisfy the needs of the national economy and will not ensure energy supply reliability.

The volume of operations completed by contracting organizations in 1978 came to 96 percent of the plan quota.

The basic reasons conditioning the non-fulfillment of the volume of construction and installation operations are: shortcomings in the planning of contracting jobs; untimely issuing of planning and estimate documents; shortcomings in organization of material and technical supply and the use of resources; an inadequate level of utilization of construction engineering; inadequate organization of labor and use of manpower.

As is shown by an analysis of the enumerated reasons, fulfillment of the plan for contracting jobs greatly depends on the style and methods of management of construction.

In 1978 the plan assignment for growth in labor productivity with respect to the 1977 level was fulfilled by 102.9 percent with a plan figure of 105 for the USSR Ministry of Power as a whole.

During the years of the 9th Five-Year Plan the actual average labor outlays for the sector in terms of 1 kilowatt of introduced capacity at heat and nuclear electric power plants were increased by 23.1 percent (by comparison with 1970) and in 1975 came to 4.77 man-days, including 3.99 in construction. At the same time at the foremost construction projects the labor outlays came to a total of 2-2.5 man-days. In the 10th Five-Year Plan this indicator actually has not changed: in 1977 the labor outlays came to 4.86, including in construction 4 man-days.

Reduction of the construction periods has especial significance in raising the effectiveness of capital construction.

Despite the existing positive experience of reducing the times for construction of electric power plants by comparison with the established norms (the Ladyzhinskaya and Zaporozhskaya GRES, Rostovskaya TETs-2, and others), the actual duration of construction of the majority of power projects put into operation exceeds the standard by 1.5-2-fold, which, naturally, leads to an increase in the level of unfinished construction (see table).

Indicators	1976	1977	1978
Capital investments, %	100	128	129
Unfinished construction, %	100	117	128
Volume of construction and installation jobs, %	100	113	127
Construction and installation jobs in unfinished production, %	100	103	116
Including with the contractor, %	100	138	317

Note: Indicators cited for the beginning of the year.

In evaluating the possibilities of increasing the effectiveness of power engineering construction, it should be kept in mind that the overall duration and cost of construction of power facilities depend to a considerable degree on the technical level of the accepted planning decisions, the times of development and the quality of the issued planning documentation.

Despite the fact that in the USSR Ministry of Power there are considerable scientific and engineering forces, the operating system of planning does not fully meet the modern demands of development of the sector.

Many power engineering facilities are still being erected according to individual plans. The low level of unification and standardization of the basic design-technological solutions stipulates in turn a low level of industrialization, an increase in materials-intensiveness and growth in unproductive outlays of labor in construction.

The planning of electric power plants is sometimes drawn out so much that the plan is "morally out-dated" even before the start of its realization.

Being introduced at extremely slow rates is the method of variant planning of power facilities, although there are positive examples of its use. Thus, during planning of the TETs of the Tobol'sk NKhK [petrochemical complex ?] by specialists of the Riga department of TEP [All-Union State Institute for Planning Electrical Equipment for Heat Engineering Installations] improvements were made in the layout and structural decisions adopted in the plan of the Ural'sk department of VNIPIenergoprom [All-Union Scientific Research and Planning Institute of the Power Engineering Industry]. According to preliminary estimates, the labor outlays for erection of the heat and electric power plant (TETs) owing to this will be reduced from 1.67 to 1.3 million man-days, and the specific labor outlays will come to two man-days per 1 kilowatt of installed capacity.

It is necessary for Glavniiproyekt [Main Administration of Scientific Research and Planning Organizations], for the planning institutes more widely to disseminate progressive solutions during the planning of other such projects. However they are hindered by considerations of prestige and poor coordination on the part of the head institutes. Being drawn out is the review of existing norms of planning power facilities, in which increased dimensions and areas of buildings, and distances between individual assemblies and structures are provided, as a result of which the indicators of utilization of the volume of the buildings of the main wings and the territory of the facilities are approximately 1.5-fold lower by comparison with the best foreign ones.

Despite the large volumes of work with respect to temporary construction bases and the significance which they have for construction, the situation regarding them leaves much to be desired. It is enough to say that even for electric power plants with identical capacity and analogous energy blocks the layout and assembly of temporary facilities of individual industries are different. The designs of such buildings are very labor-intensive. Permanent facilities are inadequately used for the needs of construction, and so on. Such a situation is explained first of all by the absence of a sufficient number of standard plans of temporary buildings and structures providing for the use of progressive structural parts. For these reasons the times for erection of construction bases are being drawn out.

There are serious complaints against the planning organizations of Glavniiproyekt in relation to the quality and times for giving planning documentation to the builders.

Thus, as of 1 January 1978 construction organizations of the USSR Ministry of Power were not provided with planning and estimate documentation worth 170.8 million rubles, including worth 83.2 million rubles for underway power engineering facilities.

The documentation executed by planning institutes as before has essential shortcomings. Often altered or additional documentation is issued already in the process of construction, which causes the necessity of alteration of structural elements and leads to an increase in outlays of manual labor at the site of the construction.

In addition, it is necessary to consider irregular the practice when large trusts, carrying out the construction of uniform projects, serve a number of departments of planning institutes which issue different planning decisions, and provide for structural parts of different types for identical projects. Thus, the Dal'energostroy trust is served by five planning organizations: the Khabarovskaya TETs is planned by the Rostov department of TEP, the Primorskaya GRES is planned by the Novosibirsk, the Yuzhno-sakhalinskaya TETs is planned by the Kiev VNIPIenergoprom, and the Blagoveshchenskaya TETs is planned by the Irkutsk VNIPIenergoprom. For the Moscow TETs with units with a capacity of 250 megawatts the institutes of Mosenergoproyekt and Teploelektroprokekt issue different planning decisions, which does not make it possible to work up the technology of construction and installation, and lowers the effectiveness of construction.

The high demands made on the planning documentation stipulate the necessity of a radical restructuring of the organization of planning matters in the sector.

Developed in the USSR Ministry of Power was an expanded program of improvement of scientific research, the planning and technology of construction, supporting the development of power engineering up to 1990. Envisaged in it, in particular, are the following:

To proceed to long-range planning of planning and research coordinated with the plan of development of electric power engineering for the long-term future;

To concentrate the necessary planning forces and financial means on development of series plans of TES [thermal electric power plants], AES [nuclear power plants] and GAES [pumped storage power plants], and standard plans of electrical network projects and residential settlements;

To insure invariability of series plans, equipment, structural parts and technology in the course of 6-7 years with subsequent replacement of them with new, more improved plans;

To work out more detailed technical requirements for the creation of new and the modernization of existing basic and auxiliary technological equipment of electric power plants, having provided here for their standardization, and also an increase in the indicators of economy, reliability and repairability, a reduction in the dimensions and use of materials, enlargement of the unit capacity of power blocks, a rise in the degree of plant readiness, block construction and completeness of deliveries;

To automate individual processes of planning and to insure a transition to an automated system of planning objects of construction (ASPOS; avtomatizirovannaya sistema proyektirovaniya ob"yektov stroitel'stva).

The decisions adopted are good, however their realization is still proceeding at slow rates.

Still not all the equipment supplied for electric power plants has reached with respect to technico-economic indicators the level of the best world standards, and the scientific research and planning organizations do not have enough influence on the technical policy in the area of improvement of existing and creation of new power engineering equipment. The equipment is not always supplied in full sets.

A rise in the effectiveness of public production is directly connected with improvement of planning on all levels of administration. However, as is evidenced by the analysis, there are serious shortcomings in planning.

When drawing up the title lists of electric power engineering projects frequently no account is taken of the normative length of construction, as a result of which the number of simultaneously erected projects increases from one year to the next, and the times for construction are drawn out. Thus, by 1978 the number of projects being erected at the same time rose to 3146 (1,788 projects in 1976), which led to scattering of material and technical and financial resources and to lengthening the times for construction of power engineering projects. Violation of the normative length of construction at the stage of compilation of the title lists and the plans of capital construction is expressed in a reduction of the volumes of capital investments and construction and installation jobs with respect to years of construction by comparison with the volumes envisaged by the norms, and in an increase in the overall length of construction in comparison with the normative length.

The results of the work regarding underway projects are affected especially negatively by the nonfulfillment of the plan, which became chronic in preceding years when these projects were carry-over projects. It is enough to say that in the fourth quarter of 1978 it was planned to put into operation 83 percent (of the annual plan of introduction) of the capacities and 49 percent (of the total length) of overhead lines with a voltage of 35 kilovolts and higher.

In some cases the allocation of means is performed without taking into account the actual volumes of construction and installation jobs with respect to the underway complex, which creates definite difficulties for timely putting of energy capacities into operation.

Fulfillment of the volumes of construction and installation jobs is planned, as a rule, without considering the actual production capacities of construction organizations, and the construction and installation organizations do not insure their own development under the increasing volumes of construction and installation jobs.

In organizations of the USSR Ministry of Power there still exists the faulty practice of intra-construction scattering of material and labor resources. Thus, in 1978 the construction administration of the Smolensk Nuclear Power Plant simultaneously erected 108 projects, which is 22 percent more than in 1977; the construction administration of Dneprokanalenergostroy built 838 projects with the average volume of construction and installation jobs at 89,500 rubles.

The scattering of resources leads to lowering the level of engineering preparation, lowering the labor productivity of the workers, makes the organization of material and technical supply difficult and so on. For the purpose of eliminating this situation it is necessary for scientific research and planning institutes to conduct serious work for creation of a fundamentally new method of drawing up multi-variant plans of capital investments and contracting jobs with the use of electronic computers. Realization of this method will insure:

Observance of a normative length of construction;

Putting production capacities and fixed capital into operation in the instructed periods;

Coordination of plan assignments with the actual capacities of contracting organizations and allocated material and financial resources and, on the contrary coordination of the rates of increase of the capacities of contracting organizations with prospective planning tasks;

Fulfillment of the plan with respect to started construction projects.

As is shown by the practice of recent years, annual planning of the volumes of construction and installation does not meet the demands of intensification of power engineering construction. In connection with this it is necessary for the Chief Planning and Economic Administration to speed up the preparation for the changeover to two-year planning in the sector, that is to change over to new methods of planning beginning in 1981.

In addition, the need has arisen to work out measures for reducing the times of bringing the planning assignments to the executors and for control over their fulfillment. Requiring further treatment are the questions of material and administrative responsibility for the quality of planning at all levels of administration.

Scientifically-based norms and standards are an important tool of planning, which will insure compilation of a plan meeting the demands of intensity and stability, of balance of the different sections and indicators.

The presently existing norms and standards according to composition and structure do not answer fully the modern demands of organization and administration of construction. The basic part of the overall system of standards is made up of the estimated norms and standards. However the plan standards are still far from fully worked out, and the existing production norms have become out-dated. Certain of the existing standards are inadequately substantiated and do not correspond to the foremost level of development of technology and economics.

Improvement of planning on the basis of balance of the plans and increasing their scientific substantiation can be attained owing to a transition from working out individual standards to the creation of a system of normative information taking into account all the chief functions of administration, including planning. Creation of such a system is possible only with the participation of all planning and scientific research institutes of the sector without exception and with broad use of the means of computer technology.

One of the basic factors determining the length of construction of projects is the level of organization of job performance, on which depends to a significant degree the fulfillment by construction organizations of the planning assignments with respect to the basic technico-economic indicators of production and economic activity. A yearly analysis of the results of the activity of organizations of the USSR Ministry of Power in the 10th five-year plan indicates that there are unsolved problems in the technology, organization and administration of power engineering construction.

Recently gaining more and more significance are the questions concerning the structure of the construction industry and the administration of construction. It is necessary to include among these the specialization of construction and installation organizations, production technology completion, dispatching, and automation of control processes.

To a considerable degree the effectiveness of the operation of the sector depends on the structure of administration of the construction industry.

Operating at the present time in the USSR Ministry of Power is a four-unit system of management of capital construction. This structure of management has been improved in the course of a long period and basically has proven itself. Observed in recent years has been an increase in the number of organizations operating according to this system. Thus, while in 1971 included in the fourth unit of administration were 52 construction administrations, in 1978 their number increased to 102. Thes organizations perform about 30 percent of the volume of construction and installation jobs, while small construction administrations annually use about 10 million rubles of capital investments.

However it is necessary to note also a number of shortcomings of such a system, negatively affecting the effectiveness of management, increasing the number of AUP [expansion unknown] and leading to duplication of the functions of the administration. In particular with the four-unit structure:

The agencies of administration of the middle unit--the main production administrations--are not fully allotted economic rights; they do not have the right to formation of financial and material reserves, they have no material interest in improvement of the economic indicators of subordinated organizations;

There is a significant number of small construction and construction and installation organizations, which have practically lost their power engineering construction profile (Tselingidrostroy, Astrakhan'gidrostroy and others);

Large enterprises of the construction industry are dispersed among the construction main administrations.

Taking into account what has been said, it appears necessary to work out and introduce a general scheme of administration of capital construction and the building industry. In this case it is necessary to insure:

A transition to a two-or three-unit system of administration;

Concentration of building collectives;

Growth in sectorial and technological specialization;

A rise in the level of management of the sector.

The growth in the volumes of construction and installation and complication of the system of intersectorial and intrasectorial communications demand the broad introduction when developing management systems of methods of mathematical economics with the use of electronic computers. Under modern conditions it is necessary to expand the field of application of electronic computers for the solution of different problems, particularly optimization problems, providing the greatest effectiveness in the system of management of the construction industry.

The technology of construction in many ways determines the labor intensiveness of the construction process and, consequently, also the times for erecting projects. Unfortunately, it is not meeting the level of the problems raised. Thus, the existing design solutions and the technology of building earthworks and underground parts of buildings of TES require considerable labor outlays for their implementation.

It is necessary more decisively to introduce progressive methods of performing the basic types of construction and installation jobs.

It is necessary for planning institutes to review the lay-out and design solutions of earthworks and underground parts of buildings for the purpose of extensive introduction of progressive technological processes, of further improvement of the structure and make-up of the machine fleet utilized during construction, taking into account the possibilities of increasing the proportion of high-capacity self-propelled scrapers, hydraulic excavators with detachable mounted equipment, rippers for frozen and rocky soils, pneumatic punches and so on.

In thermal power engineering construction the technology of performing concrete and reinforced concrete works has a direct effect on the labor intensiveness and times for construction of thermal electric power plants (TES). However improvement of the technology of concreting in recent years has not been done fast enough: still preserved is a high proportion of manual labor (about 45 percent) and a low output per worker.

For elimination of the existing deficiencies it is advisable:

To expand the manufacture of reinforced concrete modules at rayon bases and plants of the construction industry, which will make it possible to reduce the losses of reinforced steel 8-10-fold, to reduce labor outlays for manufacture of structural parts 3-4-fold and to lower the cost by 40-50 percent;

To insure further introduction of the progressive technology of laying concrete mixture in structural parts of thermal electric power plants and nuclear power plants using automatic concrete pumps with manipulators, with complex mechanization of the packing and leveling of concrete surfaces, which will make it possible in the given type of jobs to reduce labor outlays and the times of execution 2-3-fold;

To improve the design of stock concrete forms and insure mass manufacture of them at enterprises of the USSR Ministry of Power, which will make it possible to lower labor outlays for their installation and dismantling 1.5-2-fold.

Operations for installation of construction parts in thermal power engineering construction have reached significant volumes: 4.5-5 million tons are installed every year. The output per one worker in the last three years has risen by 12 percent, however labor outlays for installation of construction parts are still high.

A reduction of labor outlays will be furthered by:

Carrying out the installation of construction parts using supplied modules of full plant readiness with joinings of an increased level of technology (this will make it possible to lower labor outlays by 15 percent);

Introduction of non-aligning large-block installation of structural parts of buildings of thermal electric power plants, and the utilization of new high-capacity installation cranes with a load moment of up to 3500 ton-meters (labor outlays in this case will be reduced by 20 percent).

In the period examimed there was no essential reduction in the labor outlays for fulfillment of the most labor-intensive finishing, roofing and hydro-insulation operations.

For the purpose of a significant reduction in the labor intensiveness of these operations it is necessary to have extensive introduction of:

Industrial methods of finishing, including with the use of sheet materials (for instance, with a clean finished surface), insuring a rise in labor productivity by 3-8-fold;

Plastering stations like the "Salyut-2," making it possible to mechanize single-layer plastering and to insure reduction of outlays of manual labor by not less than 2.5-fold;

Apparatus for vacuum spraying of paint mixture, making it possible to reduce the expenditure of materials and labor outlays by 25-30 percent;

Method of performing finishing operations under plant conditions;

Shaped polyethylene instead of glued waterproofing, which will make it possible to reduce labor-outlays 7-fold.

In addition, broad introduction of roofing panels with a high degree of plant readiness will make it possible to reduce labor outlays at the construction site 2-fold.

The results of the contracting activity of the USSR Ministry of Power in 1978 were negatively affected by the inadequately high level of material and technical supply and utilization of physical resources. In 1978 not met repeatedly were the deadlines for deliveries of basic construction materials. In addition, there are grounds to assume that nonfulfillment of the volumes of deliveries of materials is an important, but not the determining factor for the breakdown in fulfillment of plan assignments with respect to the volume of construction and installation jobs.

The construction organizations of the USSR Ministry of Power have considerable reserves of prefabricated reinforced concrete and metal structural parts. Thus, as of 1 October 1978 the remainders with respect to construction metal structural parts came to 178,400 tons or 116 days worth (according to the standards--45 days), and with respect to prefabricated reinforced concrete 1,186,000 cubic meters, or 77 days worth (according to the standards, 34 days).

The main reasons for the presence of above-norm reserves of structural parts and rolled metal are:

Incomplete delivery, including nonfulfillment of orders, and interruptions in the times of delivery of prefabricated reinforced concrete and metal structural parts (up to 55 percent of the total volume of above-norm reserves);

Nonfulfillment of the plan for construction and installation jobs (up to 20 percent);

Untimely delivery of structural parts (up to 15 percent);

Change by the clients in the title lists of construction projects (up to 30 percent) and the delivery of non-liquid items (up to 9 percent);

Deficiencies in the organization of job fulfillment (up to 10 percent).

In this way, the construction organizations are not utilizing satisfactorily the available resources. The trusts are distributing them inefficiently among the subordinate organizations and construction sites, that is, without taking into account the possibilities of their utilization.

In many construction organizations the production-technical norms of expenditure of materials are not being observed. Mortars and concretes of inflated brands (against the plans) are being used. Thus, required for the majority of types of plastering jobs is mortar of brand 25, and practically at the construction sites mortar of brands not lower than 50 is being used. The average overexpenditure per one cubic meter comes to 118 kilograms. The situation is the same with the output of commercial concrete (the output of concrete of brands 50 and 75 has practically ceased).

A significant overexpenditure of cement is stipulated by the use of unwashed and unfractionated fillers. For the USSR Ministry of Power as a whole the expenditure of unwashed coarse filler came to about 70 percent of the total expenditure, that of unclassified sand came to 30 percent, and that of unwashed sand came to 28 percent. Such a situation leads to an increase in the expenditure of cement by approximately 200,000 tons.

In many construction organizations and at enterprises of the construction industry they have not set up normative accounting and reporting about the expenditure of building materials; there is no effective system of material incentive for a saving of materials and structural parts; there are gross violations of the requirements for their warehousing and storage.

A further increase in the effectiveness of power engineering construction is einseparably connected with improvement of the system of material and technical supply and the supply of full complexes in the sector. Practice has shown that the most efficient form of management of the supply of full complexes at the level of the trust is the UPTK [upravleniya proizvodstvenno-tekhnicheskoy komplektatsii; administration of production-technical supply of complexes]. In the near future it is necessary to provide for the creation of UPTK in all construction trusts without exception.

Also come to a head is the question of the creation in the system of the USSR Ministry of Power of a single agency for supply of complexes, while under the conditions of considerable geographic dispersion of construction projects it is possible to set up territorial centers of an administration for the supply of complexes. Improvement of the system of supply of complexes is a complicated process, connected with considerable organizational restructuring of the administrative bodies, and therefore its development should proceed in stages, and it is necessary first of all to transfer to the system of technological supply of complexes the projects in electrical network construction.

The overall nonfulfillment of the volume of construction and installation jobs in 1978 was stipulated to a significant degree by the shortcomings in the use of construction equipment. The shift factor of the use of construction equipment is at a low level. In the course of the last three years the shift factor of individual types of construction equipment did not increase and came to 1.5 for excavators and bulldozers, 1.7 for caterpillar cranes, 1.2 for truck cranes and so on.

Growth in the productivity of construction machinery is being held back by the great intrashift downtimes of the equipment, which in recent years have increased (the annual loss of working time of these machines comes to more than 1-1.2 million machine-hours). In this connection I would like to recall that reduction of intrashift losses just by 1 percent is equivalent to the release of 800 people and to an increase in labor productivity by approximately 0.2 percent.

The increase in the productivity of construction equipment is also being held back by the low quality and the considerable duration of repairs (1.5-2-fold greater than the normative). Centralized services for technical maintenance of machines and mechanisms are being introduced slowly at construction sites. As has been shown by the experience of Kuybyshevgidrostroy and Tatenergostroy, the introduction of these services makes it possible to reduce two-fold the non-plan downtimes of construction equipment for repairs and to reduce by 30 percent the expenditure of spare parts.

Further improvement of the utilization of construction euuipment under the conditions of a shortage of manpower is possible owing to the annual write-off of worn construction equipment and the transfer of the released machine operators to a productive section of the fleet of mechanisms with a corresponding increase in the shift factor of its utilization.

Also not utilized effectively enough is motor vehicle transport: at the present time intrashift downtimes of motor vehicles come to more than 22 percent. The existing fleet of trailers is poorly used. The coefficient of their release on the line comes to 0.49 with the coefficient of release of motor vehicles at 0.62.

The volume of freight hauling on motor-vehicle trailers in the course of many years has remained at the same level and comes to a total of only 2.5 percent of the total volume of hauling by motor transport.

As has already been remarked, one of the causes holding back a further increase in the effectiveness of power construction is the significant share of manual labor, which in the last four years practically has not been reduced and comes to 40.3 percent.

The greatest volume of manual labor falls to the performance of such jobs as concrete work, earthwork, plastering, painting, carpentry, roofing and certain others, in which more than 100,000 people are employed.

It is necessary to state that the institutes of Glavniiproyekt are giving little attention to questions of mechanization of manual labor.

The overall results of fulfillment of the program of contracting jobs in 1978 were negatively affected by the shortage of workers employed in basic production, which on the average per year come to 13,400 people. For this reason alone construction and installation jobs worth 150 million rubles were not carried out. The shortage of labor resources is conditioned basically by the intensive construction of power engineering projects in the little-developed regions of Siberia, the Far East, and Central Asia.

Along with this the organizations of the USSR Ministry of Power have not used such an important source of covering the shortage of manpower in basic production as the redistribution of the number owing to the personnel employed in maintenance and other services.

The number of workers employed in maintenance and other services of construction and installation production, with respect to the number of workers employed in basic production, has constantly increased in recent years: 37.1 percent in 1970, 46.4 percent in 1975, and in 1978 it reached 51.5 percent which, naturally, is not proper.

Under the conditions of a shortage of manpower the questions of organization of labor and utilization of working time take on especial significance. However in 1978 the losses of working time by comparison with preceding years of the 10th Five-Year Plan increased, and the annual fund of working time was poorly utilized.

One of the important forms of organization of labor is the brigade contract. However thescope of its introduction in the USSR Ministry of Power is still on a low level. Covered by this form of labor organization is approximately 15 percent of the number of workers (about 20 percent of the volume of operations performed while only 1 percent growth in the volume of operations performed according to the method of the brigade contract would make it possible to release about 800 people and perform an additional volume of construction and installation jobs worth 6 million rubles).

One of the main causes of the high turnover of personnel (in 1978 it was 29.5 percent) are the unsatisfactory social and everyday living conditions at the construction sites, since the plans for introduction of housing and facilities for social, recreational and domestic use are not being fulfilled.

The peculiarities of the demographic development of the country have stipulated the necessity of priority solution of the questions connected with attachment and utilization of labor resources. Here especial significance is taken on by the development and unconditional fulfillment of complex plans of social development of labor collectives.

Thus, it is necessary for enterprises and organizations of the USSR Ministry of Power to activate the work in the field of improving the planning, organization and management of construction, to use existing reserves and insure unconditional fulfillment of the quotas of the 10th Five-Year Plan in the field of power engineering construction.

10908
CSO: 1822

ELECTRIC POWER AND POWER EQUIPMENT

UDC 621.31.002.2

PLANNING 500-MEGAWATT UNITS FOR REFTINSKAYA GRES OUTLINED

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 6, Jun 79 pp 7-9

[Article by B.M. Tsymkin, engineer: "Experience in Planning 500-Megawatt Power Blocks for the Reftinskaya GRES"]

[Text] From the editorial board: Close creative cooperation of planning institutes (Ural department of Teploelektroproyekt, the Novosibirsk department of TsNIIproyektstal'konstruktsii) and of construction and installation organizations (Uralenergostroy, Uralenergomontazh, Ekektrouralmontazh, Uralenergokhimzashchita, Uralspetsenergomontazh), and the critical analysis of the experience of construction of the Troitskaya GRES, these are the factors which have insured fulfillment of the engineering and organizational preparation of construction and installation of the power blocks with a capacity of 500 megawatts in the second phase of the Reftinskaya GRES on a high level. Achieved in the course of erecting the second phase of the Reftinskaya GRES was a significant reduction in the length of construction, a reduction of the materials-intensiveness of structural parts and reduction of labor outlays. The positive experience of such cooperation is being realized today during preparation for construction of a number of other GRES with high-capacity power blocks, particularly the electric power plants of the Ekibastuz and Kansk-Achinsk TEK [fuel and power complexes] and the Tyumen' power complex.

Considering the unquestionable importance of wide dissemination of this positive experience to the construction of all large electric power plants, the editorial board is starting the publication of materials generalizing the experience of construction of the second phase of the Reftinskaya GRES.

The Reftinskaya GRES is located in the valley of the Reft river (figure 1), northeast of the city of Asbest. Ekibastuz coal serves as the fuel for the electric power plant. The water-supply system is a return one with a reservoir. Ash-trapping is accomplished using electrofilters (provided for blocks Nos. 7 and 8 are four-field electrofilters of the EGZ-4-265 type with electrodes 12 meters high, and for blocks 9 and 10, five-field filters). Removal of ash and slag (joint) is hydraulic. Two ash-slag dumps are provided for storing the slag and ash.

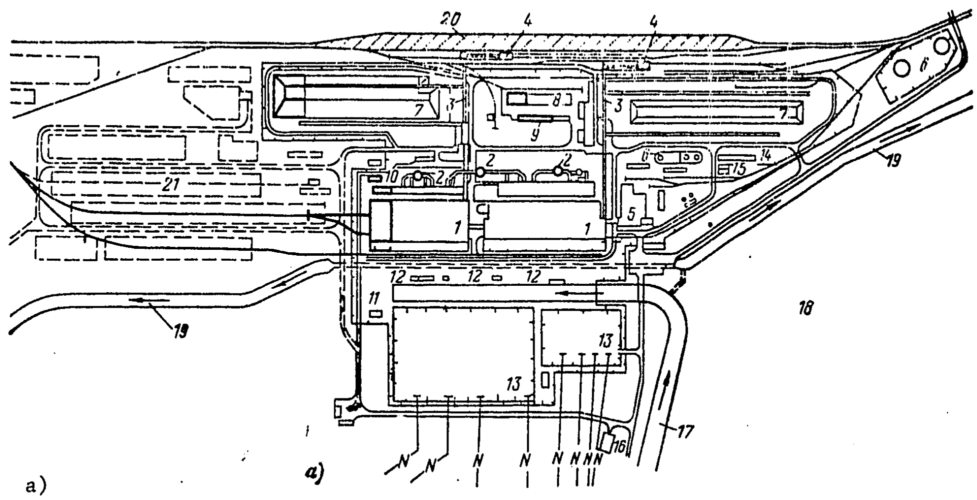
For the purpose of creating and working up planning decisions of 500-megawatt power blocks operating on Ekibastuz coals, intended for the Reftinskaya GRES and electric power plants of the Ekibastuz power complex, in 1974 a pilot power block was introduced at the Troitskaya GRES.

The blueprints of bock No. 7 of the Reftinskaya GRES (first block with a capacity of 500 megawatts) were developed taking into account the experience in planning, construction, installation and adjustment of the pilot power block of the Troitskaya GRES. Representatives of the planners and operators were at the construction site during the installation, assimilation and operation of the pilot power block.

In addition, the technical solution for 500-megawatt blocks were worked up by the planners and power machine builders in close cooperation (for instance taking part in development of the layout of the power block were representatives of the Ural department of Teploelektroproyekt, the ZiO [Podol'sk Machinebuilding Plant imeni Ordzhonikidze], and the Special Design Bureau of the All-Union Institute of Heat Engineering imeni Dzerzhinskiy). This made it possible to create a rational layout of the basic and auxiliary equipment in the main building (figure 2). The basic technico-economic indicators of the plans are cited in table 1.

The Reftinskaya GRES will be part of the system of Sverdlovenergo. Output of capacity in the system is accomplished through four lines with a voltage of 220 kilovolts and three of 500 kilovolts. The basic characteristics of the electric power plant are presented below:

Total capacity	3800 megawatts
Including for phases:	
I	1200 (4 X 300 - 240) megawatts
II	2100 (2 X 300 - 240) megawatts (3 X 500 - 240)
III	500 (1 X 500 - 240) megawatts
Distance of fuel transport	1450 kilometers
Area of surface of the reservoir	25.3 square kilometers
Volume of the reservoir	141.96 million cubic meters
NPU [normal backwater level]	178 meters



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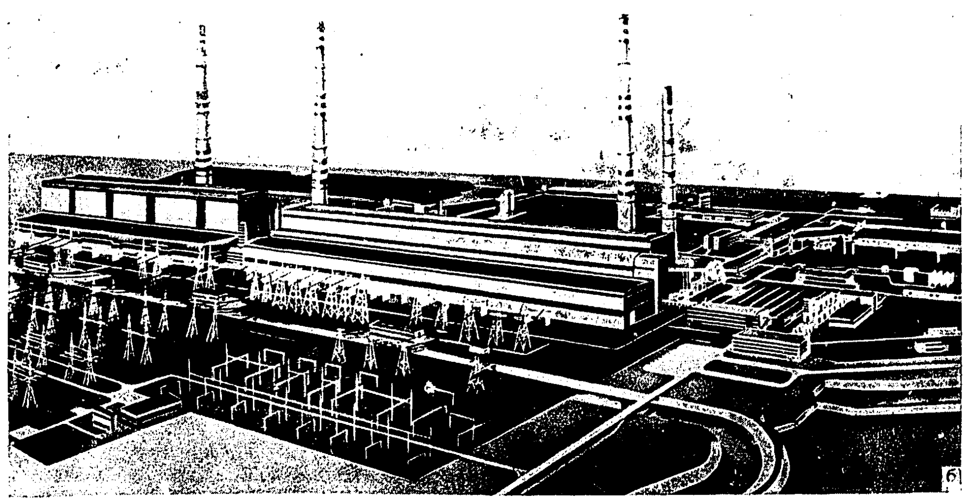

b)

Figure 1. Master plan (a) and overall view (b) of the Reftinskaya GRES.

Key: 1. Main building
2. Smokestacks
3. Fuel supply loop
4. Car dumper
5. OVK [expansion unknown]

[continued on following page]

Key to figure 1, continued:

6. Mazut department
7. Coal storage
8. Materials storage
9. General shop workshops
10. Domestic building
11. Workshops of the electrical shop
12. Block pumps
13. Open distributing devices
14. Start-up boiler
15. Equipment repair block
16. Substation construction
17. Head race
18. Reservoir
19. Offtake
20. Unloading site
21. Territory of construction base

The technical plan of phase II was worked out by UralTEP in 1970-1971. Completed in 1978 was the single-stage design of expansion of the GRES (phase III) up to a capacity of 3800 megawatts, envisaged by which are the times for construction of the blocks (start and completion): No. 7, 1974 and 1977; No. 8, 1977 and 1978; No. 9, 1978 and 1979; and No. 10, 1978 and 1980.

It should be noted that the planning of the 500-megawatt blocks both for the Troitskaya and for the Reftinskaya GRES was carried out in one complex planning division of UralTEP. In order to check the adopted design criteria a mock-up of the block was made. By photographing the mock-up it was possible to reject the working out of labor-consuming assembly drawings.

As a result of analysis of the experience in planning 500-megawatt blocks at the Troitskaya GRES (specification of loads) during the planning of analogous blocks of the Reftinskaya GRES the width of the columns of rows B and D was reduced from 2500 to 2250 millimeters, and thanks to this the expenditure of metal at each power block was lowered by 1,000 tons. In addition, used in the plan for the main building of the Reftinskaya GRES was a new design of roofing, making it possible to perform block installation. Installed in the boiler department was a slotted skylight. Air heaters were installed in the exterior walls of the boiler and machine departments for heating and ventilation of the main building.

Envisaged for power blocks Nos. 8-10 is the installation of a new TVM-500 generator with oil cooling of the stator. Envisaged at blocks Nos. 9 and 10 is a tubular air heater instead of an RVP [possibly: finned air heater].

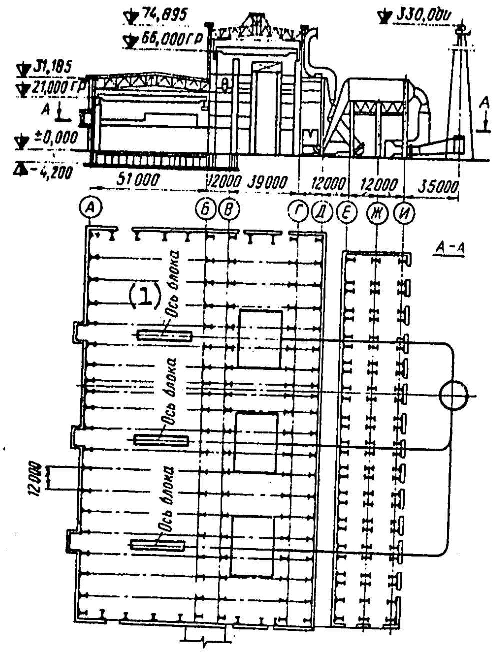

Figure 2. Cross-section of Main Building

Key: 1. Axis of block

In distinction to the Troitskaya GRES, where provided for servicing all mills of the dust conditioning system is an installation with two ventilators for primary blowing of cold air, at the Reftinskaya GRES it was decided to install on each mill an individual ventilator for primary blowing of hot air.

Overhead covers are provided for convenience of maintaining the pipelines in the built-in stack at the points of 16.69, 20.00 and 23.82 meters. Provided in the system for control of the block is automation of individual working operations of the technological equipment making up the functional groups.

Organized at the construction site of the Reftinskaya GRES was a worker planning group which performed the author's inspection and gave current technical assistance. The quantitative and qualitative make-up of the group changed depending on the state of the construction and installation operations.

Table 1.

Indicators	Troitskaya GRES	Reftinskaya GRES[1]
Planned capacity, megawatts	1000	2100
Annual distribution of electric power, million kilowatt-hours	6280	13025
Expenditure of electric power for in-house needs, %	3.49	4.59
Number of hours of use of electric capacity, hours	6500	6500
Specific expenditure of standard fuel for electric power released, grams/kilowatt-hr	335	335
Annual expenditure of crude fuel, million tons	3.6	7.3
Specific prime cost of released electric power, kopecks/kilowatt-hour	0.525	0.552
Specific number of personnel, men/megawatt:		
Total	0.38	0.41
Including operations personnel	0.26	0.18
Specific capital investments in industrial construction, rubles per kilowatt	134.6	119.3

Note: [1]Indicators are cited for phase II as a whole taking into account two blocks of 300 megawatts each, since the indicators have not been calculated for the 500-megawatt blocks individually.

The permanent composition of the group was 9 people. According to the degree of unfolding of construction and installation operations the group was filled out with the corresponding specialists (heat engineers, electricians, adjusters of the control and measuring instruments and automatic equipment), who were at the site until the introduction of the power block. In the peak period of construction and installation operations the make-up of the group was increased to 12-15 people.

The work of the group for worker planning and author's inspection was headed by the chief engineer of the project, who was on site in the course of the year preceding the year of introduction of the block. The labor outlays for conduct of the author's inspection and rendering technical assistance during erection of block No. 7 (by years of construction) are presented in table 2.

Table 2.

Labor Outlays	1975	1976	1977
Total man-days	311	889	2394
Including by specialties:			
Builders	118	378	657
Technologists	150	476	482
Electricians	--	9	416
Adjusters of control and measuring instruments and automatic equipment	--	--	635
Others	43	26	204

In conclusion it is necessary to stress once more that successful fulfillment of the assignment regarding erection of the power blocks with a capacity of 500 megawatts was furthered by the purposeful joint work of the planners and the specialists of the manufacturing plants of the basic equipment of the GRES.

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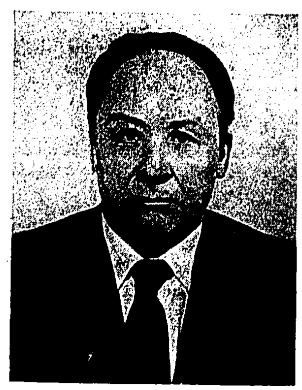
ELECTRIC POWER AND POWER EQUIPMENT

P.P. FALALEYEV HONORED FOR POWER ENGINEERING WORK

Moscow ENERGETICHESKOYE STROITEL'STVO in Russian No 6, Jun 79 p 77

[Article: "On the 60th Birthday of Pavel Petrovich Falaleyev"]

[Text] Pavel Petrovich Falaleyev, First Deputy Minister of Power Engineering and Electrification of the USSR, has celebrated his 60th birthday. One of the most active organizers of power engineering construction in our country, he has been a member of the CPSU since 1957.



P.P. Falaleyev was born on 12 June 1919. In 1938 after completing evening secondary school he began the first course at Moscow Power Engineering Institute. In July 1941, that is, in the first days after the beginning of the Great Patriotic War, together with all the students of the institute he took an active part in construction of defense facilities near the city of Vyaz'ma, and in August of the same year he joined the ranks of the people's volunteer corps as a volunteer. In December 1941 P.P. Falaleyev was sent to continue his training at the Moscow Power Engineering Institute, which he completed in 1943.

After graduating from the institute, P.P. Falaleyev worked for more than 20 years in the system of the Uzbekgidroenergostroy Trust both directly at the construction site and in the apparatus of the trust, traversing the difficult road from rank-and-file foreman to manager of the trust.

In 1953 he was sent for training to the Power Engineering Academy, which he completed successfully in 1955.

In 1967 P.P. Falaleyev was appointed Minister of the Construction Materials Industry of the Uzbek SSR, and in November 1968 he became First Deputy Minister of Power Engineering and Electrification of the USSR.

The high businesslike qualities of P.P. Falaleyev, the creative energy, varied knowledge, vast love for work, the ability to work with the collective and flexibly solve the most complex organizational and technical engineering problems have advanced him into the front ranks of the leaders of domestic power engineering construction.

In addition to the organization of power engineering construction, P.P. Falaleyev takes an active part in the management of the building of such major national economic projects as the Volga and Kama motor vehicle plants and others. At the present time he is in charge of the work for construction of projects for the Olympics in the city of Moscow.

P.P. Falaleyev is the editor-in-chief of the main publication of the Ministry in the field of construction--the symposium ENERGETICHESKOYE STROITEL'STVO. He is the author of many articles published in the central and sectorial press, in which problems of power engineering and electrification of the country are treated and concrete ways are determined for increasing the effectiveness and improving the quality of power engineering construction.

For great services to power engineering construction and the development of power engineering and electrification of the country, P.P. Falaleyev has been awarded the Order of the October Revolution, two orders of the Labor Red Banner, three orders of the "Badge of Honor," medals, and also Honorary Certificates of the Presidiums of the Supreme Soviet of the Uzbek SSR, Tadzhik SSR and Turkmen SSR. The honorary title of "Honored Builder of the Uzbek SSR" has been conferred on him.

P.P. Falaleyev successfully combines extensive production activity with considerable public work. He has been elected a deputy of the Moscow City Soviet of People's Deputies.

P.P. Falaleyev has been awarded the Order of Lenin by ukaz of the Presidium of the USSR Supreme Soviet dated 15 June 1979 for great services to the development of power engineering and electrification of the country and in connection with his 60th birthday.

In congratulating Pavel Petrovich Falaleyev on this glorious date, we wish him with all our heart good health, prosperity and further creative successes in his fruitful activity for the good of our great homeland.

10908
CSO: 1822

FUELS AND RELATED EQUIPMENT

CONFERENCE HELD ON SIBERIAN PETROLEUM, GAS

Moscow GEOLOGIYA NEFTI I GAZA in Russian No. 6, Jun 79, pp 57-59

[Article by A. A. Bakirov, E. A. Bakirov, A. V. Shashin, Yu. V. Samsonov (Moscow Institute of the Petrochemical and Gas Industry imeni Academician I. M. Gubkin), and N. P. Dobrynina (NEDRA): "Conference on the Geological Principles of Forecasting the Petroleum and Gas Content of the Siberian Platform"]

[Text] On 21-23 November, 1978, a scientific and technical conference on the problem of "The Geological Principles of Forecasting the Petroleum and Gas Content of the Siberian Platform" was held in the city of Shushenskoye in Krasnoyarskiy Kray. The conference was called by the Central Board of the Scientific and Technical Society of the Petroleum and Gas Industry imeni I. M. Gubkin and the Scientific Council for the Problems of the Geology and Geochemistry of Petroleum and Gas of the USSR Academy of Sciences jointly with the USSR Ministry of Geology and the RSFSR Ministry of Geology and with the participation of the "Gorchoye" Scientific and Technical Society, the All-Union Petroleum Scientific Research Institute of Geological Exploration, the Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials, the All-Union Scientific Research Institute of the Economics of Mineral Raw Materials and Geological Exploration, the East Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials, the Institute of Geography and the Russian Hydrological Institute, the All-Union Scientific Research Institute of Gas, the Moscow Institute of the Petrochemical and Gas Industry imeni Academician I. M. Gubkin and Moscow State University, the production organizations of the RSFSR Ministry of Geology, and others.

Eighty people participated in the conference, including 45 doctors and candidates of geological and mineralogical sciences, executive workers from branch ministries and scientific research institutes, and leading geologists and geophysicists from production organizations.

The conference examined the present state of research on developing the geological principles for forecasting the petroleum and gas content of the Siberian platform in order to increase the effectiveness of prospecting work for petroleum and gas on this territory.

The introductory words were spoken by the chairman of the Organizational Committee professor A. A. Bakirov who characterized petroleum and gas prospecting work on the Siberian platform and considered the basic task of petroleum and gas geological science.

The conference participants heard and discussed 7 reports on the important problems of the region's petroleum and gas geology: "The State of Research and its Future Tasks Regarding the Geological Principles of Forecasting the Petroleum and Gas Content of the Siberian Platform" (V. V. Zabaluyev, All-Union Petroleum Scientific Research Institute of Geological Exploration); "The Basic Features of the Tectonic Structure of the Siberian Platform in Connection with Petroleum Geological Regionalizing" (V. S. Starosel'tsev, the Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials); "The Structure of the Sedimentary Mantle of the Siberian Platform and the Regional Conditions for Spreading Collectors and Impenetrable Complexes in it" (V. N. Kirkinskaya, All-Union Petroleum Scientific Research Institute of Geological Exploration); "The Petroleum and Gas Content of the Sedimentary Mantle and the Prospects for Discovering New Petroleum and Gas Bearing Areas and Zones of Petroleum and Gas Accumulation on the Siberian Platform" (K. K. Makarov, All-Union Petroleum Scientific Research Institute of Geological Exploration; V. V. Samsonov, VSGU; V. Ye. Bakin, Yakutsk Petroleum and Gas Prospecting; V. D. Nakaryakov, Krasnoyarsk Petroleum and Gas Prospecting); "The Scientific Principles and Criteria for the Individualized Forecasting of the Petroleum and Gas Content of the Siberian Platform" (A. E. Kontorovich, Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials); "Geophysical Methods of Studying the Geological Structure of Various Regions of the Siberian Platform" (V. S. Surkov, Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials; S. L. Arutyunov, East Siberian Scientific Research Institute of Geology, Geophysics, and Mineral Raw Materials); "The Theoretical Criteria for Searching for Zones of the Concentration of the Largest Stocks of Petroleum and Gas in Connection with the Selection of Optimal Directions for Petroleum and Gas Prospecting on the Siberian Platform" (A. A. Bakirov, Moscow Institute of the Petrochemical and Gas Industry imeni academician I. M. Gubkin).

The conference heard reports by A. I. Gritsenko and V. F. Gorbacheva (All-Union Scientific Research Institute of Gas), E. M. Khalimov (Ministry of Petroleum Industry), V. V. Semenovich (USSR Ministry of Geology), A. V. Obcharenko (RSFSR Ministry of Geology), and representatives of the production and scientific research organizations which are performing work in Eastern Siberia and Yakutiya.

After a discussion of the reports, the conference adopted a full-scale decision aimed at increasing the effectiveness of geological surveying work and at the most rapid preparation of proven stocks of petroleum and gas for the creation of mining centers on the territory of the Siberian platform.

In the certifying part of the decision it is noted that in recent years the production organizations of the RSFSR Ministry of Geology and the Scientific Research Institutes of the USSR Ministry of Geology, the Siberian Branch of the USSR Academy of Sciences, the USSR Ministry of Higher Education, and the Ministry of Gas Industry have performed substantial research in studying the geological structure and evaluating the petroleum and gas content of the Siberian platform. As a result of this research, a general study has been made of the geological structure and history of the development of the platform and of the hydrogeology of the deposits and the geochemistry of the scattered organic matter and light has been thrown upon the general conditions of the dissemination and structure of petroleum and gas bearing complexes and on the basic features of the structure of open petroleum and gas deposits. A solution has been found for the general problems of forecasting petroleum and gas content in application to the specific characteristics of the structure of the Siberian platform, summary maps have been made up of tectonic and petrogeological regionalizing and of the petroleum and gas content prospects, a quantitative estimate of petroleum and gas content has been made, and the directions have been mapped out for individualized forecasts of petroleum and gas searches.

Geological surveying work on the Siberian platform has established the industrial productivity of Risey,Vend, and Lower Canbrian deposits (the Angoro-Lenskaya phase, Nepsko-Botuobinskaya and Baykitskaya anteclises), Mezozoic and upper Paleozoic deposits (the Vilyuskaya syneclise and the Yenisey-Khatangskiy regional downwarp), and of Paleozoic deposits (the Nordvikskiy Rayon of the Leno-Anabarskiy regional downwarp and the Turukhanskiy Rayon of the Priyeniseyskaya zone of linear dislocations). Thus, the regional petroleum and gas content of vast territories of the platform has been proven for a wide stratigraphic range.

At the same time, the conference noted that there are definite shortcomings in the performance of geological and geophysical work on the Siberian platform. Thus, to this day, despite the long history of prospecting work for petroleum and gas (more than 40 years), the level at which geological and geophysical studies have been carried out on the region remains uneven and very low. The average drilling density on the platform is .64 meters/square kilometer, which is approximately 17 times less than the average deep drilling density in the USSR as a whole. The basic drilling work was concentrated in the Yenisey-Khatangskiy (in its western part), Vilyuiskaya (at the Khapchagayskiy megaval) the Nepsko-Botoubinskaya (in the Prilenskiy and Mirninskiy areas) and the Angara-Lenskaya petroleum and gas-bearing areas. In the other areas of the Siberian platform only individual wells have been drilled and the drilling density comes to .001-.08 meters/square kilometers. In the central and northern areas of the Tunusskiy syneclise which are promising in their petroleum and gas content not a single deep well has been drilled. Parametric and support drilling comes to only 13.8 and 2.6 percent.

The basic drilling work within large zones of petroleum and gas accumulation was concentrated at individual open deposits, which did not ensure an even study of auspicious territories, inclines, and surrounding depressions.

More than half of the territory of the platform has not been covered with regional geological and geophysical work. Only 20 percent of its auspicious land has been covered with area seismic surveying. The preparation by geophysical methods of a fund of structures for prospecting and surveying drilling is retarded.

In the field of scientific research work the basic shortcomings are a lagging in the development of the theoretical principles and methodologies for a differentiated evaluation of auspicious and forecasted resources of petroleum and gas with a validation of the zones of their maximum concentration and slowness in developing and introducing new highly effective methods and methodologies for prospecting for large zones of petroleum and gas accumulations under diverse geological conditions.

The conference called attention to the fact that the research of the institutes of the USSR Ministry of Geology, Ministry of Petroleum Chemical Industry, Ministry of Gas Industry, USSR Academy of Sciences, and USSR Ministry of Higher Education are insufficiently coordinated. This is lowering their overall effectiveness.

The conference addressed a request to the USSR Ministry of Geology to strengthen the coordination of scientific research work on the geology and petroleum and gas content of eastern Siberia.

In the concluding part of the decision the conference mapped out a number of recommendations aimed at deepening, expanding, and accelerating the solution of important theoretical and methodological problems and, above all, the development of the scientific principles of forecasting and of selecting optimal directions for prospecting and surveying work for petroleum and gas.

The conference noted that the petroleum-geological regionalizing of the Siberian platform has to be carried out on a geotectonic basis with regard to the special characteristics of the structure and history of the geological development and formation of its large structural elements, and that regional petroleum and gas bearing complexes have to be singled out with regard to the paleotectonic, paleogeographic, paleochemical, paleohydrogeological, and paleogeothermal conditions of their formation and development during the individual stages of their geological development in the various parts of the platform.

It was recommended that scientific research institutes expand their overall theoretical research in studying:

a cross-section of the sedimentary mantle, the capacity and filtration properties of collectors, especially carbonate collectors, the conditions for the formation and mutation of their properties, and also the screening properties of difficult to penetrate complexes;

the history of the formation and development of large geostructural elements and the prospects of their containing petroleum and gas on the basis of summary documents (regional cross-sections, paleotectonic, paleogeographic, paleohydrogeological, and other maps, diagrams of the inter-area correlation of typical cross-sections, and so forth);

the laws of the formation and development of zones of petroleum and gas accumulation, especially of the maximum concentration of UV [expansion unknown], and also of deposits of gas and petroleum with regard to the specific characteristics of the structure of the sedimentary mantle of the platform.

One of our most important tasks is an improvement of the methodology for a quantitative differentiated evaluation of a petroleum and gas content forecast, including separate forecasts for petroleum and gas with the singling out of possible large zones of petroleum and gas accumulation.

The decision also points to the necessity for improving the methods and methodologies of prospecting and surveying petroleum and gas accumulation zones and petroleum and gas deposits, including snares of the structural and non-structural type, and a complex of geophysical and geochemical methods of prospecting deposits, and also the necessity for accelerating the development of a complex of seismo-surveying, electrosurveying, and well apparatus.

In order to increase the results and economic efficiency of prospecting and surveying work the conference proposed increasing the amounts of exploratory, parametric, and prospecting drilling and ensuring the outstripping development of regional and prospecting geophysical studies for the purpose of a reliable geological substantiation of the optimal directions of prospecting and surveying work and the most rapid elimination of lagging in the preparation of a fund of structures for deep drilling.

In order to increase geological effectiveness and the result of geophysical work the decision emphasizes the necessity for a wide introduction of modern methods of seismo-surveying, electrosurveying, and high-current gravity surveying, a shift by seismic groups to digital recording, and other measures.

The conference attributed considerable importance to the development and expensive introduction of geophysical field studies which make it possible to distinguish productive strata in a carbonate cross-section and to determine their porosity, effective capacity, petroleum content, and other parameters, to strengthening scientific research and designing work aimed at improving the equipment and technology of creating wells, and to expanding scientific research on the economics of geological surveying work of all types and at all stages, including the development of the principles and criteria of evaluating economic efficiency.

The conference attributed especial importance to the necessity for creating an appropriate production, technical base which will ensure the planned growth of geophysical and drilling work as early as the 10th Five-Year Plan.

The conference called upon the collectives of production and scientific research organizations and upon the scientific and technical public to make every effort to carry out the decisions of the 25th CPSU Congress regarding an acceleration of the discovery and surveying of new petroleum, gas, and condensate deposits in Eastern Siberia and the Yakutsk ASSR.

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